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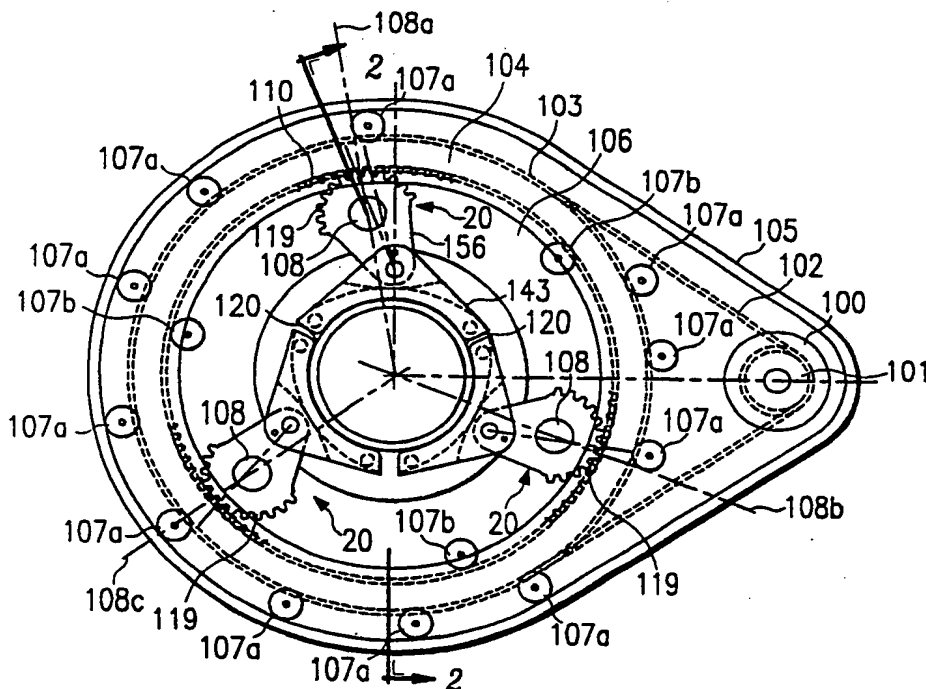
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**(54) Title:** POWER TONGS WITH IMPROVED GRIPPING MEANS



**(57) Abstract**

Power tongs and back-ups are disclosed which have improved means for gripping pipe and tubular members. Torque is applied and held with minimum damage to the pipe or tubular member. A plurality of gripping assemblies (20), each consisting of a pivoted jaw (143) having a friction surface, are mounted on a drag ring (106). Rotational resistance is selectively applied to the pipe (120). Various modifications of the gripping assemblies (20) are disclosed to provide better gripping contact with the pipe (120).

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## POWER TONGS WITH IMPROVED GRIPPING MEANS

## TECHNICAL FIELD

The present invention relates to power tongs and back-ups which have improved apparatus for gripping pipe and tubular members in general. More specifically, the present invention relates to power tongs in which the gripping apparatus minimizes deformation of the tubular member as well as damage to the tubular member caused by the jaw members gouging or sliding along the surface of the tubular member.

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## BACKGROUND AND SUMMARY OF THE INVENTION

Power tongs are devices used to secure together ("make up") and detach ("break out") threaded ends of two adjacent tubular products, such as pipe sections, by gripping, applying torque to and rotating one of the sections. Other devices, known as back-ups, are often used in conjunction with such tongs to grip and hold against rotation the other of the two adjacent sections of pipe.

In recent years, major oil companies have required their drill string pipes or tubular products be screwed and torqued together without damage to the tubulars, so that stress and corrosion concentrations will not occur in the tears and gouges in the tubulars caused by the tong and/or back-up teeth. In addition, to maintain integrity of the threaded connection, it is desirable to reduce deformation of the pipe by the power tongs and back-ups near the location of the threads, thus allowing more compatible meshing of the threads and reducing frictional wear.

Commonly owned Reissue Patent No. 31,993, which issued on October 1, 1985 as a reissue of U.S. Patent No. 4,281,535, describes means to accomplish the task of making and breaking the threaded joints of such tubular members and is incorporated herein by reference for all purposes. The terms "pipe" or "tubular" element as used herein shall include tubing and other cylindrical objects.

Gouging and tearing of pipe is caused in some instances by a number of undesirable conditions that cause concentration of the gripping force applied by the tong or back-up. For example, one such condition is insufficient contact area between gripping teeth of the tong or back-up and the pipe. Another is inadequate contact by one or more of a number of gripping members which engage the pipe, causing the gripping force to be concentrated with and applied by the remaining members. Still further, the gripping surface presented to the pipe may not conform in radius to the outer

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diameter of the pipe, causing uneven distribution of the gripping force across the surface of the pipe and concentrations at drastically reduced contact areas between the pipe and gripping mechanism.

Misalignment of the tong or back-up with the pipe may also cause gripping force concentrations leading to pipe damage. If the tong or back-up is not aligned axially with respect to the pipe, the gripping surfaces may contact the pipe at an angle, thus causing the gripping force to be applied to the pipe along the edge of a gripping surface, for example. Typically, this damages the pipe, because the pressure applied to the pipe is concentrated in the relatively small area of contact between the gripping mechanism and pipe, instead of being spread over the entire face of the mechanism.

Considerable wear can also occur as the pipe is engaged by the tong. Many conventional tongs incorporate a gripping assembly that includes a mounting ring which supports a number of gripping members, such as dies, and that rotates with respect to a drive ring. The gripping members are actuated by rotation of the drive ring to engage the pipe. At the outset of operation, the drive ring rotates to force the gripping members into contact with the pipe surface. However, because the mounting ring is also rotatable, rotation of the gripping members relative to the pipe generally occurs as the members are driven into secure engagement with the pipe. As a result, the gripping members of such mechanisms frequently cause scraping, gouging and marring of the pipe as the members slide across the pipe while being progressively tightened by the drive ring to a frictional, stationary grip against the pipe, prior to rotation.

At least one prior art device, more fully disclosed in U.S. Patent No. 3,550,485, which issued to J. L. Dickmann on December 29, 1970, discloses a means for retarding movement of the mounting ring while the gripping members are actuated

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by the drive ring to engage the pipe. The retarding force applied to the mounting ring, however, must be manually activated, and adjusted.

Because the retarding mechanism must be manually readjusted if deactivated, it is typically engaged constantly, even during make up and break out operations. As a result, wear of all associated parts is increased unnecessarily and the longevity of the device is substantially limited. If, on the other hand, the retarding mechanism is deactivated during operations, such devices become inherently inconsistent in the application of the retarding force to the mounting ring, due to repeated manual readjustment, frequently allowing the gripping members to skid across the pipe (if the retarding force is too low) or causing the gripping members to impact the pipe with too great a force (if the retarding force is excessive). In either case, scrapping, gouging and marring of the pipe typically results.

In conventional tongs, pressure applied by the gripping jaws is not distributed evenly around the pipe, but is applied to areas spaced around the perimeter of the pipe. This causes undue deformation of the pipe as the jaws impinge against its surface. Since the jaws typically grip the pipe adjacent to threads in couplings used to secure adjacent pipe sections, the threads deform with the pipe. Such deformation causes leaks across the threads, thereby reducing the useful life of the pipe.

The present invention overcomes these and other disadvantages associated with other tongs, back-ups and similar pipe gripping apparatus. The preferred embodiment is a pipe gripping apparatus for engaging, disengaging and/or rotating pipe sections, having gripping assemblies for gripping a section of pipe without slipping, marring, gouging or tearing the pipe. The gripping assemblies pivotally support a number of jaws. The jaws are actuated into and out of contact with the pipe during make up and break out



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procedures.

The radial gripping force applied to the pipe by the jaws is proportional to the torque applied to the pipe by the gripping apparatus, such that the greater the torque applied, the greater the gripping force exerted by the jaws against the pipe. The surface areas of the jaws contacting the pipe is sufficiently great, given the maximum gripping force to be applied to the pipe, to avoid reaching or exceeding the yield strength of the surface of the pipe. The contact surfaces of the jaws may, accordingly, be smooth, equipped with gripping teeth, or the gripping apparatus may incorporate jaws having both types of contact surfaces. The jaws are sized to replace gripping dies on existing state of the art gripping apparatus.

An additional feature of the preferred embodiment is a positioning device positioned between the jaw members and the gripping assembly to which they are connected. This positioning device tends to hold the jaws, once moved to a retracted position out of contact with the pipe, in a position that will not interfere with insertion or removal of the pipe from the gripping apparatus. A further aspect of the invention is incorporation in the jaws of removable jaw sections or segments so that the entire jaw member does not have to be removed once the gripping teeth become worn or when different size jaw members would otherwise be required to match pipes having different radii. These segments are configured to seat substantially flush against the pipe member to avoid force concentrations and slippage that would likely damage the pipe.

Further, in one embodiment the jaw segments are attached to the jaw member in a manner allowing a slight play in the jaw teeth segment with respect to the jaw member so that the jaw segment can adjust itself slightly to make a relatively flush fit with the pipe. In one case, the jaw itself has a spherical connection to the gripping assembly

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which allows a slight pivoting movement of the jaw and its teeth along axes perpendicular to and parallel to the pipe, to provide a relatively flush fit.

In another embodiment, a removable adapter link is coupled between the jaws and the gripping assembly so that adapter links of various sizes can be used to enable the gripping assembly to accommodate different size pipes. This reduces manufacturing costs that would otherwise be needed for replacement jaw links and jaw members.

An additional feature is the provision of an adjustable drag on the drag ring to which the gripping assemblies are pivotally mounted. A drag force is applied to the drag ring to prevent it from rotating as a drive ring rotates to force the jaw members into engagement with the pipe. This causes the jaw members to grip the pipe with a predetermined radial force prior to the pipe being rotated. This effectively eliminates scraping, gouging and marring of the pipe that would otherwise be caused by the slippage of the jaws over the pipe surface.

Also, projecting lugs are used on certain embodiments to position the jaws out of the way of the pipe when the jaws are retracted.

Also, in the present invention, rounded corners are formed on the jaws to minimize damage caused by the jaw contacting the pipe on the edge of a gripping surface.

Another embodiment of the invention is an open throat tong utilizing three gripping assemblies rather than the two assemblies typically used by prior art devices. This causes the force applied to the pipe to be more uniformly distributed about the circumference of the pipe, distributes the force within the tong or back-up more evenly, lessens the force applied at any one point, and allows the associated jaws to more fully encircle the pipe. Jaws such as those previously discussed are pivotally mounted to the gripping assemblies.

The present invention also contemplates the use, in

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the alternative, of a special jaw link member pivotally coupled to the interface assembly. The link member has on one end a pivotal jaw and on the other end a jaw segment, both of which allow for misalignment and wear and provide a gripping surface for covering more of the pipe surface.

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## BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the present invention and the advantages thereof, reference is now made to the following description taken in conjunction with the accompanying drawings in which:

FIGURE 1A is a top view of a closed face power tong unit;

FIGURE 1B is a partial top view of a prior art closed face tong incorporating conventional dies to grip a section of pipe;

FIGURE 1C is a partial top view of the tong shown in FIGURE 1B, in which jaws incorporating the present invention are substituted for the conventional dies;

FIGURE 2 is a partial cross-sectional view taken along section lines 2-2 of FIGURE 1A, illustrating two alternative embodiments for applying friction to the drag plate to cause the jaws to engage the pipe with a predetermined radial pressure before rotation of the pipe begins;

FIGURE 3 is a side view of a preferred jaw assembly;

FIGURE 4 is a cross-sectional view of the jaw assembly taken along section lines 4-4 of FIGURE 3;

FIGURE 5 is a side view of an alternate jaw assembly illustrating removable gripping segments pivotally mounted in the jaw body;

FIGURE 6 is a cross-sectional view of the jaw assembly taken along section lines 6-6 of FIGURE 5;

FIGURE 7 is a top view of an open throat power tong with the gripping jaws in the open position;

FIGURE 8 is a schematic illustration of a hydraulic system for applying drag to the mounting ring of the tong shown in FIGURE 7 to cause the jaws to engage the pipe with a predetermined radial pressure before rotation of the pipe begins;

FIGURE 9 is a partial top view of an open throat

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power tong illustrating the gripping jaws in their extended position, engaging the pipe for rotation;

FIGURE 10 is a cross-sectional view of the open throat power tong taken along section lines 10-10 of FIGURE 9;

FIGURE 11 is a partial side view of another alternate embodiment of the gripping assemblies used in the tong of FIGURE 10;

FIGURE 12 is a partial side view of still another alternate type of gripping assembly that can be used in the tong of FIGURE 10;

FIGURE 13 is a side view of yet another alternate gripping assembly that can be used in the closed face power tong;

FIGURE 14 is a cross-sectional view of the alternate gripping assembly of FIGURE 13, taken along section lines 14-14 of FIGURE 13 and illustrating a first design for pivotally supporting an associated jaw;

FIGURE 14A is a cross-sectional view of the alternate gripping assembly of FIGURE 13, taken along section lines 14A-14A of FIGURE 13 and illustrating a second design for pivotally supporting an associated jaw;

FIGURE 15 is a partial side view of still another preferred embodiment of a jaw assembly;

FIGURE 16 is a cross-sectional view of the embodiment of FIGURE 15 taken along section lines 16-16; and

FIGURE 17 is a partial side view of the assembly illustrated in FIGURE 15 utilizing an alternate means of gripping a pipe.

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## DETAILED DESCRIPTION OF THE DRAWINGS

FIGURE 1A is a top view of a closed face tong unit comprising a preferred embodiment of the invention. A conventional drive system uses fluid motor 100 to drive sprocket 101 that causes roller chain 102 to turn sprocket 103 forming part of final drive gear or ring 104. Drive gear 104 rotates within housing 105 on cam rollers 107A, some of which are shown in FIGURE 1A, attached to housing 105 around the periphery of final drive gear 104. Drag ring 106 rotates concentrically within final drive gear 104 on cam rollers 107B, some of which are shown in FIGURE 1, attached to final drive gear 104 around the periphery of drag ring 106. Final drive gear 104 is concentric with the tubular surface of pipe 120. Drag ring 106 has a plurality of pins 108 which may or may not be equally spaced around drag ring 106. Three equally spaced pins 108 are preferred. Pins 108 may contain grease fittings 109.

A plurality of gripping assemblies 20 (or 21 of FIGURES 3 and 4; or 26 of FIGURES 13, 14, and 14A; or 28 of FIGURES 15 and 16) fit over pins 108, engaging gear teeth 110 on final drive gear 104. Each gripping assembly includes a jaw 143 pivotally connected to a jaw link 156 that is, in turn, pivotally connected at pin 108 to drag ring 106.

In the embodiment shown in FIGURE 1A, the gripping assemblies 20 should maintain substantially identical rotational positions with respect to the center of the pipe 120. This ensures that the gripping assemblies 20 will grip the pipe 120 at a location substantially at the center of rotation of the final drive gear 104. Proper relationship of pins 108 to drive gear teeth 110 is illustrated in Figure 1A by lines 108A through 108C, which intersect the center of the pipe 120, intersect the center of the pipe 108 and bisect a tooth of gear 110. Gear teeth 119 of each gripping assembly 20 mesh with gear teeth 110 of final drive gear 104 so as to position each of the gripping assemblies 20 substantially

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identically relative to their respective lines 108A-C and to pipe 120 as final drive gear 104 rotates.

FIGURE 3 illustrates a preferred means of properly positioning the gripping assemblies 20 (only one shown) with respect to the pipe 120. The components of the gripping assembly 20 are arranged such that a center line 170A passes through the center of pin 108, passes through the center of jaw pivot pin 157 and bisects a space between teeth 119 of each assembly 20. This relationship applies to all other gripping assemblies disclosed herein for use with tongs having similar final drive gears having internal teeth.

FIGURE 1B illustrates a prior art closed face tong 10 incorporating five gripping dies 12 spaced substantially equally about the perimeter of the tong 10. The dies 12 each have convex gripping surfaces 14 which engage a pipe section 16 inserted into the tong 10. The dies 12 are pivotally supported on a mounting ring 18 by a pivot pin 19.

It will be apparent that the prior art tong 10 has an inherent propensity to mar, gouge and tear the surface of the pipe 16. Specifically, the convex surfaces 14 of each gripping die 12 contact the pipe 16 only along a relatively small area, thereby concentrating the gripping force in many instances beyond the yield strength of the surface of the pipe 16. In addition, the use of five gripping dies 12 often results in uneven gripping forces being applied by the dies 12 to the pipe 16, as the gripping surfaces 14 of the dies 12 frequently wear unevenly. This further concentrates the gripping force with the gripping dies 12 more fully contacting the pipe 16, thus increasing damage to the pipe 16. Moreover, the relatively small contact area between the gripping dies 12 and the pipe 16 requires a relatively larger gripping force to be asserted against the pipe 16 to avoid slippage, thereby contributing to damage of the pipe 16.

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FIGURE 1C illustrates an arrangement of three (3) gripping assemblies 20, substituted for the five gripping dies 12 of the prior art tong 10. This is accomplished by removing the dies 12 and inserting three of the assemblies 20, on three of the five (5) pivot posts 19. Pivotaly mounted on each of the gripping assemblies 20 is a jaw 143 for engaging and gripping a pipe 16. Because no three of the posts 19 are spaced evenly about the tong 10, the jaws of the assemblies 20 are sized accordingly, in this application, to maintain separation in operation, and also to engage the pipe 16 along substantially all of its perimeter. The gear teeth 119 of the assemblies 20 are driven by a drive gear (not shown) of the tong 10, in the same way as prior art dies 12, to engage, disengage and apply torque to the pipe 16. It will be apparent that gripping assemblies 21, 24, 26 and 28 (discussed in detail within), with appropriately sized jaws, can also be similarly incorporated in the prior art tong 10 in place of the gripping dies 12.

FIGURE 2 is a partial cross-sectional view of the closed face tong unit taken along lines 2-2 of FIGURE 1A, in which pivot posts 108 are spaced substantially equally about the perimeter of the tong. Cover plate 111 fits over pins 108 and into slot 111A of final drive gear 104 to retain assemblies 20 to provide additional support, along with drag ring 106 for radial loads produced by the gripping assemblies. Cover plate 111 is retained by removable housing plate 112 which contains grease seals 113 and 114. Seals 113, 114, 115 and 116 keep grease within the tong housing 105.

Gripping assemblies 21, 26 and 28, can also be substituted for assemblies 20 in the tong of FIGURE 2, as alternative embodiments. The following discussion of the construction and operation of the tong of FIGURE 2 generally applies to the embodiments incorporating assemblies 21, 26 and 28.



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In operation, assuming the gripping assemblies 20 (or 21, 26 or 28) to be in the retracted position, final drive gear 104 is rotated clockwise by motor 100. The rotation of drag ring 106 is resisted by either the fluid friction assembly 22 illustrated at the top of FIGURE 2 or with a fluid motor assembly 23 illustrated at the bottom of FIGURE 2. Either assembly allows the amount of rotational resistance of drag ring 106 to be controlled. When final drive gear 104 is rotated clockwise, internal gear teeth 110 are engaged with jaw gear teeth 119, causing gripping assemblies 20 to rotate clockwise toward the tubular surface of pipe 120 as illustrated in FIGURE 1A. Drag ring 106 will not rotate until a predetermined rotational resistance caused by either assembly 22 or 23 is overcome by torque on final drive gear 104. This action allows the gripping assemblies 20 to be rotated clockwise (FIGURE 3) causing each gripping jaw to move inwardly to engage the tubular surface of pipe 120.

Conversely, when final drive gear 104 is rotated counter clockwise, the gripping assemblies 20, are rotated counter clockwise and the gripping jaws 143 move outwardly away from the tubular surface of pipe 120 and are completely retracted. The amount of predetermined rotational resistance on drag ring 106 determines the radial preload or force of assemblies 20, 21, 26 or 28 on the tubular surface of pipe 120 before the drag ring 106 is allowed to turn further and apply torque to pipe 120. The predetermined force is sufficient to prevent movement of the jaws relative to the pipe as the pipe is rotated. This action prevents teeth skid marks on the pipe such as scraping, gouging, etc., since the pipe will not rotate or be moved until the predetermined preload pressure has been applied to the pipe. Pipe 120, of course, may also be a coupling or other tubular or solid object and such are included herein.

Resistance assembly 22 provides resistance to drag ring 106 by the use of fluid power as shown in the upper

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portion of FIGURE 2. The resistance assembly 22 can be used in conventional and other prior art tongs, in addition to the embodiment disclosed herein, to control gripping and release of a pipe. When fluid motor 100 (the drive motor in FIGURE 1A) is activated by valve 121 in one direction with fluid pressure in line 122, line 123 is also pressurized through check valve 124. Sequencing valve 125 is adjusted so that the fluid pressure applied to motor 100 will reach a predetermined amount of pressure (which determines torque) before valve 125 opens to allow pressure to actuate pilot operated valve 126. Pilot valve 126, when activated, allows pressure from source P to be coupled to line 129 and which causes fluid cylinder 126 to retract and release brake shoe 117 from drag ring 106 so that drag ring 106 can rotate.

When control valve 121 is in the position shown, motor 100 is not activated and the pressure through the lower portion of pilot valve 126 is coupled to adjustable sequencing valve 127. Valve 127 controls the force of the fluid applied to cylinder 128 coupled to brake shoe 117 on drag ring 106. Pilot valve 126 may also operate brake bands (not shown) on the drag ring 106. Thus, a predetermined frictional force is applied to drag ring 106 through brake shoe 117 to resist rotation of drag ring 106.

When control valve 121 is reversed, pressure is applied through line 130 to motor 100 in the opposite direction and line 123 is then pressurized through check valve 131. Again, when a predetermined pressure is reached, sequencing valve 125 operates valve 126 and the brake shoe is released as described earlier.

Thus, in summary, when pressure is first applied through control valve 121 to motor 100 to rotate it in either direction, pressure through pilot valve 126 is holding the brake shoe 117 against drag ring 106 and prevents it from rotating. As the fluid pressure driving motor 100 builds up or increases, a point is reached at which valve 125 opens thus

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operating pilot valve 126 to cause the fluid pressure to reverse directions through cylinder 128 and release brake shoe 117 from the drag ring 106, thus allowing the drag ring 106 to turn. In such case, while drag ring 106 is stationary, the drive ring 104 is turning to move the gripping assemblies 20, 21 into or out of contact with the tubular surface of pipe 120. When a certain predetermined radial gripping pressure on the pipe 120 is reached as determined by the pressure setting of sequencing valves 125 and 127, the brake shoe 117 is released and drive ring 104 causes drag ring 106 to turn and rotate pipe 120.

If the motor 100 is turning in such a direction as to cause the gripping assemblies to be moved away from the tubular surface of pipe 120, it will be noted that the gripping assemblies are moved completely away from the pipe 120 before brake shoe 117 is released as determined by the pressure setting of sequencing valves 125 and 127 and drag ring 106 begins to turn thus protecting the tubular surface of pipe 120 from being scratched or scraped by the teeth on the gripping assemblies. Further, this action moves the gripping assemblies out of the path of any subsequent axial movement of the pipe 120 such as the removal or insertion of a pipe. In like manner, when the motor 100 drives the drive ring 104 clockwise to force the gripping assemblies against the tubular surface of pipe 120, drag ring 106 cannot rotate until the gripping assemblies are in contact with the tubular surface of pipe 120 with a predetermined radial pressure. Then drag ring 106 will rotate the pipe 120, thus preventing the gripping assembly teeth from slipping on the tubular surface of pipe 120 and causing damage. It can be seen that the drag ring 106 remains fixed until the gripping assemblies have completely removed themselves from or come in contact with the tubular surface of pipe 120 with a predetermined radial force, to protect the pipe from damage.

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The preferred method of providing the rotational resistance to drag ring 106 is by the use of fluid power assembly 23 illustrated at the bottom portion of FIGURE 2. The fluid power assembly 23 can be used in conventional and other prior art open and closed face tongs, in addition to the embodiment disclosed herein, to control gripping and release of a pipe. In this case, a fluid motor 118 (preferably a vane type fluid motor) has a gear 132 which engages a gear 133 on drag ring 106. When torque is applied in one direction to drag ring 106 by drive gear 104, motor 118 attempts to rotate and therefore acts as a pump that pressurizes line 134. Motor 118 feed is provided through check valve 136 and line 135 to fluid reservoir 137. Motor 118 cannot rotate until it pressurizes line 134 to a predetermined pressure as determined by adjustable fluid relief valve 138. Thus, drag ring 106 cannot rotate until motor 118 rotates and motor 118 cannot rotate until it builds up a pressure in line 134 that exceeds the pressure setting of relief valve 138. Relief valve 138 is adjustable to control the torque required to rotate motor 118 and by controlling the torque of motor 118, the resistance of drag ring 106 to rotation is also controlled.

When torque is applied in the opposite direction to drag ring 106, motor 118 is rotated in the opposite direction, pressurizing line 139 and creating suction through line 140 and check valve 141. When a preset pressure is reached as determined by relief valve 142, valve 142 opens and motor 118 is allowed to turn thus removing the resistance to drag ring 106 and allowing it to turn at a predetermined torque.

With the use of fluid power assembly 23, there is a constant resistance to rotation of drag ring 106 during the interval of time in which the gripping assemblies are making or breaking contact with the tubular surface of pipe 120. This assures that gripping assemblies 20, 21 or 26 will be held tightly against, or completely released from, tubular surface of pipe 120 before beginning to rotate, thus

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preventing slippage of the gripping assemblies on the tubular surface and causing scrape, scratch, and gouge marks or the like. The use of the fluid power assembly 23 provides therefore the same advantages as the fluid friction assembly 22.

In reference to FIGURES 3 and 4, it will be seen that FIGURE 3 is a side view of a gripping assembly 20 and FIGURE 4 is a cross-sectional view of the gripping assembly 20 of FIGURE 3. Gripping assembly 20 consists of a jaw 143 having a removable jaw insert 144 between the tubular surface of pipe 120 and jaw 143. Insert 144 is slipped over dowel 145, that is part of jaw 143, to secure the insert 144 against torque forces that will occur between jaw 143 and jaw insert 144. Jaw insert 144 is aligned by the sides 146 and 147 of jaw 143 and secured by screws 148 and 149. It will be noted that jaw insert 144 has rounded corners 150, 151, 152 and 153 to prevent jaw teeth 154 from damaging the tubular surface of pipe 120 during engagement thereof. In some cases, a shim 155 may be used to compensate for wear of assembly 20 and pins 108 and 157. Also, by providing shims 155 having a gripping surface with a radius that varies from shim to shim, a different force angle 170 can be created merely by inserting a shim 155 having the proper radius. Moreover, shims of appropriate radius may also be used to maintain a flush seat against pipes of different outer diameters.

Jaw 143 is rotatably mounted to jaw link 156 by a pin 157 secured by snap rings 158 and 159. Lubricating means are provided by grease fitting 160 and passage 161. If preferred, jaw teeth 154 may be cut directly into jaw 143 with no jaw insert 144 being used.

To balance forces applied by the jaw 143 to the pipe 120, the pin 157 of the assembly 20 may be positioned at a location on jaw 143 other than that shown in FIGURE 3, as desired. A similar adjustment can be made, as desired, to the pivot points of the jaws of assemblies 21, 26 and 28.

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Jaw link 156 is pivotally mounted to drag ring 106 by pin 108. Gear teeth 119 of jaw link 156 engage internal teeth 110 of final drive gear 104. When final drive gear 104 is rotated clockwise, drive gear teeth 110 engage jaw link gear teeth 119, causing jaw link 156 to rotate clockwise about drag ring pin 108. Torque resistance applied to drag ring 106, by either drag assembly 22 or 23, prevents movement of drag ring 106, causing jaw link 156 to urge jaw 143 radially inwardly into engagement with the tubular surface of pipe 120. The amount of drag on drag ring 106 is preset through drag assembly 22 or 23 and determines the amount of preload torque of jaw 143 on the outer surface of pipe 120 before actual torquing of pipe 120 begins. Thus, the outer surface of pipe 120 is protected from damage by the jaw teeth.

When the final drive gear 104 is rotated in the opposite direction, jaw 143 is retracted from the pipe 120 in reverse order of the procedure set forth above.

Thus it will be seen that the drag assemblies 22 and 23 prevent the drag ring 106 and the jaws 147 from turning until the gripping surface teeth are in or out of contact with the tubular surface of pipe 120, thereby protecting the outer surface of pipe 120.

Other improvements are also shown in FIGURE 3 with respect to gripping assembly 20. When jaw 143 is retracted and free of contact with pipe 120, it tends to pivot freely about jaw pin 157, and thus may not retract evenly. If it retracts unevenly, pipe 120 may not be able to slip axially into the inside diameter 162 of drag ring 106. Thus if jaw 143 happened to be pivoted about pin 157 such that either outer end of jaw 143 containing lug 166 or 167 protruded toward the interior of the area to be occupied by pipe 120, pipe 120, when axially inserted into the center of the closed face tong, may contact that portion of jaw 143 protruding into the area to be occupied by pipe 120, causing damage to the

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pipe or preventing pipe 120 from being axially inserted into the closed face tong.

The present invention solves this problem with a positioning device in jaw 143 consisting of a dowel 163 urged against jaw link 156 by a spring or an elastomer plug 164 that is compressed by a set screw 165. The dowel 163, which may be steel or another durable friction material, is used to frictionally control the position of jaw 143. As jaw link 156 rotates jaw 143 away from pipe 120 and toward the inside diameter 162 of drag ring 106, lug 166 or 167, each extending from a respective outer end of the jaw 143, first encounters the inside diameter 162 of drag ring 156. Continued rotation of jaw link 156 forces jaw 143 to overcome the friction caused by dowel 163 and aligns jaw 143 concentrically with the inside diameter 162 of drag ring 106. Lugs 166 and 167 may be on the opposite side (on the upper surface facing the reader) of jaw 143 from that shown, if desired, such that they engage the inside diameter of cover 111.

A second member of controlling the positioning of jaw 143 during retraction from or engagement with pipe 120 comprises springs 168 and 169. Alternatively, these springs may be torsion springs (not shown) or other suitable type of spring. Each spring is secured between an attachment point on jaw link 156 and an attachment point on jaw 143. The spring tension of spring 168 may be greater than that of spring 169 to hold the jaw 143 in the position shown in FIGURE 3 as it is retracted by the counter clockwise rotation of jaw link 156. When the jaw 143 is extended inwardly by the clockwise rotation of link 156, contact of the outer ends of jaw 143 with the pipe 120 will allow the jaw 143 to center itself about the tubular outer surface of pipe 120.

In some cases, it is possible that only one spring 168 may be needed to center jaw 143 as indicated.

The radial gripping force of jaw 143 along perpendicular 171 to pipe 120 is both proportional to the

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torque applied by final drive gear 104 to the jaw link 156 and is a function of the cosine of force angle 170. The preferred radial force along perpendicular 171 that is sufficient to set the jaw teeth on the pipe may be predetermined by multiplying the tangential force 172 at the surface of pipe 120 by a factor of 0.8 through 3.0, inclusive. A ratio of 1.10 is preferred because the radial force preferably exceeds the tangential force by a factor of 0.10 to reasonably assure jaw teeth will not skid on the pipe 120. The tangential force 172 is applied torque in inch/pounds divided by the radius in inches of pipe 120. For any given desired tangential force 172, the resulting force angle 170 can then be computed in degrees. After computing desired radial force to jaw 143, the jaw teeth 154 spacing and length (width of jaw 143) can then be computed using radial force 171 so that the force applied by jaw teeth 154 does not exceed the ultimate strength of the material forming pipe 120 at the maximum required applied torque to pipe 120. This eliminates teeth marks on the pipe.

It will be noted that the applied radial load is borne by pins 108 and pins 157. No radial load is carried by final drive gear 104.

Gripping assemblies 20, 21, 26 and 28 may also be used in a tong back-up which creates torque to hold the pipe 120 when torque is applied by a power tong to an adjacent section of pipe is in the opposite direction to make or break a connection. In a tong back-up, a roller chain (not shown) may be substituted for final drive gear 104 engaging a sprocket segment (not shown) on jaw link 156 instead of gear teeth 119.

FIGURE 5 shows a side view of an alternate embodiment of a gripping assembly 21. FIGURE 6 is a cross-sectional view thereof. Gripping assembly 21 provides for a jaw link in two pieces, a jaw link gear head 173A and a jaw link adapter 173B which fits in a suitable slot in jaw link gear



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head 173A and is secured by screws 174 and 175. Shoulders 176 and 177 bear the radial load 171 during operation. Jaw link adapter 173B is separate from gear head 173A and jaw 178 to enable one gear head 173A to be used for several different sizes of pipes 120, thereby reducing the cost and effort of substituting gripping assemblies completely to accommodate different size pipe. Thus, if pipe 120 is of smaller diameter, link adapter 173B and jaw 178 can simply be replaced with a longer adapter and smaller jaw. In like manner, if the radius of pipe 120 is larger, link adapter 173B and jaw 178 can be replaced with a shorter adapter and larger jaw, thus allowing the device to accommodate the larger diameter pipe.

Further, FIGURE 5 illustrates another type of jaw 178 which facilitate flush engagement of the jaw 178 with various pipe sizes. Jaw segments 179 and 180 are contained within slots or grooves 181 and 182 in jaw 178. They are loosely restrained by screws 183 and 184. The top of slots 181 and 182 are flat, heat treated and relatively very hard (Rockwell C54 to C65). The top of the segments 179 and 180 are hardened and have an outside radii 185 and 186 concentric with pipe 120. The interior radius of the teeth 187 and 188 are also concentric with the pipe 120. Surfaces 185 and 186 roll on flat surfaces of slots 180 and 181 with enough clearance to self-adjust to fit pipe 120 and overcome minor deviations in fit. Location angles 189, 190 and 191 are predetermined to evenly balance the radial load 171 on pipe 120 imparted by each of the jaw segments utilized by jaw 178 and the segments of other jaws with which it is used. The corner radii 193 and 194 around jaw segments 179 and 180 in FIGURE 6 serve to reduce contact marks on pipe 120.

Parts of gripping assembly 20 shown in FIGURE 3 may be interchanged with gripping assembly 21. Similarly, the jaw 143 in FIGURE 3 and jaw 178 in FIGURE 5 may be used on the gripping assemblies in FIGURES 7, 9, 11 and 12.

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FIGURES 7 and 9 depict an open-throat power tong with three gripping assemblies 24 enclosed in a housing 195, and shown in their retracted positions. The gripping assemblies 24 are preferably spaced as shown at 120 degree increments, with angles 196 being 30 degrees. This spacing is preferred so that radial loads are equally distributed on the three gripping assemblies 24 and about the drive ring 197. However, it should be noted that the gripping assemblies 24 may be located such that angles 196 are between 0 degrees and 45 degrees, if desired.

A major advantage of the preferred embodiment shown in FIGURE 7 over the prior art open throat tongs is that in the prior art the radial load is divided between only two jaws, while the arrangement shown in FIGURE 7 and in FIGURE 9 allows the radial load to be generated by three gripping assemblies 24, thus reducing the radial load applied by each jaw. Further, this arrangement, which separates radial loads into three points spaced by approximately 120 degrees, reduces and distributes stress on the final drive gear 197, thereby minimizing breakage of the drive gear. In addition, the three gripping assemblies 24 as shown have sufficient arcuate length to substantially completely encircle pipe 120, to minimize damage to the surface of the pipe 120 and to reduce deformation.

Conventional hinged gate 198 is openable to allow radial entry and exit of pipe 120. Gate 198 is closed during the torquing of pipe 120. The gate 198 may be manually operated or power operated. It may have a mechanical latch (not shown) to resist radial stress on housing 195 during torquing of pipe 120.

Final drive gear 197 is driven by conventional gearing of a motor 199 with a drive gear 200, which in turn drives gears 201 and 202. Final drive gear 197, in turn, is driven by gears 201 and 202, through gear teeth 203. Final

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drive gear 197 rotates within housing 195 on a plurality of rollers 204 secured to housing 195.

The final drive gear 197 contains conventional cam surfaces 205, 206, 207, 208 and 209 (these may be either flat or arcuate, as desired) which cooperate with the three gripping assemblies 24 to grip pipe 120. The relief areas 210 and 211 in final drive gear 197 allow gripping assembly rollers 212 and 213 to retract to move the jaw assemblies sufficiently outward to allow pipe 120 to be radially inserted into and out of throat area 213. Drag ring 215 is preferably made in two parts, 216 and 217, secured by dowels 218 and bolts 219, as is best shown in FIGURE 10.

Radial passageways 275 allow gripping assemblies 24 to slide inwardly and outwardly toward and away from the center of pipe 120. Grooves 220 contain springs 221 that exert force on lugs 222 on gripping assemblies 24 to urge gripping assemblies 24 radially outwardly at all times. Drag ring 215 turns concentrically within drive gear 197 on rollers 228. As shown in FIGURE 10, drag ring 215 has a gear 223 on part 217 that engages gears 224 and 225 to drive gear 226.

Gear 226 is secured to the shaft of fluid motor 227.

The purpose of motor 227 is to provide preset rotational resistance to drag ring 215, as shown in the schematic diagram in FIGURE 8. The entire drag fluid assembly illustrated in FIGURE 8 is designated by the numeral 274. The drag fluid assembly 274 can be used in conventional and other prior art open and closed face tongs, in addition to the embodiments disclosed herein, to control gripping and release of a pipe.

Referring now to FIGURE 8, when fluid motor 227 is turned in one direction driven by rotation of drag ring 215, motor 227 acts as a fluid pump pressurizing line 229A with suction provided through line 229B, drawing fluid from reservoir 230 through check valve 231. When pressure on line 229A reaches a preset pressure determined by an adjustable pressure relief valve 232, motor 227 is allowed to turn.

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Rotational resistance on drag ring 215 is maintained by the preset pressure in line 229A.

When the fluid motor 227 is turned in the opposite direction, line 229B is pressurized with the suction provided through line 229A, drawing fluid from reservoir 230 through check valve 233. When the pressure on line 229B reaches a preset pressure as determined by adjustable pressure relief valve 234, valve 234 opens. Motor 227 is then allowed to rotate. Rotational resistance is maintained by preset pressure in line 229B, inducing rotational resistance on drag ring 215.

When the control valve 235 is activated, fluid is allowed to bypass motor 227 through line 236 thereby releasing rotational resistance when motor 227 is turned in either direction.

Referring again to FIGURE 7, final drive gear 197 and drag ring 215 are shown with gripping assemblies 24 in retracted position. Assume that the assemblies 24 are to be forced inwardly against pipe 120. In operation, motor 199 is activated through conventional fluid power controls (not shown) to rotate final drive gear 197 in a clockwise direction. Since drag ring 215 is restrained to a preset torque by the drag fluid assembly 274 and drag motor 227 illustrated in FIGURE 8, the drive gear 197 forces gripping assembly 24 rollers 212 and 213 along slopes 237A and 237B and then to cam surfaces 207 and 209. Roller 213A is forced along cam surface 205.

The three gripping assemblies 24 are designed to grip pipe 120 such that it is concentric with final drive gear 197. During the time it takes for the torque applied to drive gear 197 to reach the preset torque drag on drag ring 215, the gripping jaws are forced against pipe 120 with the desired predetermined radial force. When the torque applied to drive gear 197 reaches the preset torque drag on drag ring 215, the appropriate check valve 232 or 234 opens, the drag is

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overcome and torque is then applied to pipe 120 to rotate it. This preset torque resistance on drag ring 215 allows cam surfaces 205, 207 and 209 to apply predetermined radial gripping forces to pipe 120 before torque is applied to rotate pipe 120. This allows firm jaw engagement with pipe 120 to prevent skidding of jaw teeth on the pipe when the rotation force is applied. It also allows a large force angle (the angle measured between a radial line passing through the center of the pipe and the force vector applied to assemblies 24 by their respective cam surfaces 205, 207 and 209) on gripping assembly 24, thereby reducing radial stresses on drive gear 197. A force angle 248 is illustrated as an example in FIGURE 11. The preferred force angle for all open face tong applications disclosed will result in a ratio of radial gripping force to the tangential rotational force within the range of 0.8 through 3.0, inclusive. A ratio of 1.10 is preferred because the radial force preferably exceeds the tangential force by a factor of 0.10 to reasonably assure jaw teeth will not skid on the pipe 120.

FIGURE 9 shows final drive gear 197, drag ring 215 and gripping assemblies 24 in the position when torque is being applied to pipe 120 in the clockwise direction to rotate pipe 120 (housing 195 and other gears are not shown in this FIGURE).

To release pipe 120, final drive gear 197 is rotated counter clockwise. Since drag ring 215 is prevented from turning by torque resistance from motor 227, rollers 212 and 213 on gripping assemblies 24 retract into relief notches 210 and 211 and roller 213A retracts along cam surface 205. The notches 210 and 211 can be used in conventional and other prior art open and closed face tongs and backups, in addition to the embodiments disclosed herein, to position the gripping means utilized in such devices.

The end 276 of each of the two jaws 278 and 279 nearest the open throat 214, or a projection thereon such as

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shown in FIGURE 3, contacts the intersection of passageway 275 and arcuate inner surface 277 of drag ring 215. This contact pivots jaws 278 and 279 such that the jaw ends 280 and 281 are moved out of the open throat 214 to enable pipe 120 to be inserted in or removed from the open throat tong. A spring 282 or 283 may alternatively, or additionally, be used to assist in positioning jaw ends 280 and 281 out of the open throat 214. At this point, the open throat 214 in drive gear 197 and the throat in drag ring 215 are aligned with each other but not with gate 198. By activating valve 235, bypassing motor 227, as shown in FIGURE 8, drive gear 197 and drag ring 215 are held relative to each other by rollers 212 and 213 that are forced into notches 210 and 211 by springs 221. Thus, drive gear 197 and drag ring 215 are now rotated in unison by motor 199 until throat 214 is aligned as shown in FIGURE 7. Valve 235 is then released, shutting off motor 227 bypass.

FIGURE 11 illustrates gripping assembly 24 in more detail as a side view. As previously described, final drive gear 197 forces gripping assembly 24 to grip pipe 120. Cam surface 207 engages roller 212A supported by shaft 212B in crosshead 237. Crosshead 237 travels radially within drag ring 215 on side rollers 238, 239, 240 and 241 which reduce the radial force necessary to grip pipe 120. Alternatively, the rollers 240 and 241 can be mounted only adjacent the lower side of the crosshead 237, only adjacent the upper side of the crosshead 237, or as otherwise desired. Crosshead 237 has an opening 242 in which is inserted jaw adapter 243 secured by screw 244. The radial load between crosshead 237 and jaw adapter 243 is borne by surface 245. Jaw 246 is hingedly connected to jaw adapter 243 by jaw pin 247. The purpose of jaw adapter 243 is to allow several pipe sizes to be gripped without changing crosshead 237. Gripping assembly 24 may also be used in back-up tongs. Force angle 248 on cam surface 207

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is determined in the manner similar to that previously described for gripping assembly 20.

Jaw 246 may contain any of the features of jaw 143 in FIGURE 3, jaw 178 in FIGURE 5, jaw 265 of FIGURE 13 or jaw 300 of FIGURES 15 and 17. Further, gripping assembly 24 may be used in a closed face tong provided that the drive ring (104 in FIGURE 1 and FIGURE 3) has cam surfaces for exerting force against the crosshead 237 and does not include a throat 214.

FIGURE 12 illustrates another improvement in jaw construction for use in an open face or closed face tong. A final drive gear 249, similar to final drive gear 197 in FIGURE 11, has a cam surface 250 that engages roller 251 at a predetermined force angle 252. The force angle 252 is computed in the same manner as was done for gripping assembly 24 above. Shaft 253 supports roller 251 in link member 254 that is pivotally connected to drag ring 255 by shaft 256. Link member 254 has a cylindrically or arcuately shaped sidewall portion 257 which contains a jaw segment 258 in a slot on one end as described in FIGURES 5 and 6. It also contains a jaw 259 on the other end that is the same as previously described in relation to FIGURE 3 and FIGURE 4. Jaw 259 is hingedly connected to link member 254 by jaw pin 260. Sidewall portion 257 may have a plurality of inserts 258 and no jaw 259, if desired. Pipe gripping assembly 25 allows for misalignment with the pipe 120 because of wear of the jaw teeth and thus prevents pipe damage caused by resulting force concentrations at teeth contacting the pipe. Further, the gripping assembly 25 shown in FIGURE 12 allows more of the pipe outside diameter to be covered with a single jaw.

Part 257 may be of different sizes to fit different pipe 120 sizes. An opening 261 in part 257 enables a round post 262 on link member 254 to be inserted therein and secured by screw 263. Surface 264 bears the radial load from gripping pipe 120.

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A mechanical advantage can be obtained by moving post 262 and opening 261 to the right in FIGURE 12, thereby allowing the radial force on pipe 120 to be divided between roller 251 and shaft 256. This reduces outward radial forces on roller 251 and final drive gear 249.

FIGURE 13 is a side view of an alternate embodiment of a gripping assembly 26 and FIGURE 14 is a cross-sectional view thereof. Gripping assembly 26 differs from the other gripping assemblies in that jaw 265 is pivoted to jaw link 266 by a spherical socket 267. An opening 268 provides tool relief to allow cutting of socket or spherical surface 267. The socket 267 receives the ball shaped end 269 of jaw link 266. Jaw 265 is loosely secured to jaw link 266 by pin 270, through a loose fitting hole 271, and is secured by snap rings 272 and 273.

The loosely fitted pin 270 and opening 271 allow for axial misalignment of pipe 120 to final drive gear 104 and drag ring 106. However, a balanced gripping force is still applied from jaw 265 to pipe 120 even while torque forces are turning pipe 120. Rotational and gripping forces are applied to the socket 267 by the ball 269, thereby avoiding or minimizing shear stress that would otherwise be imposed on the pin 270. The spherical jaw pivot of gripping assembly 26 may be used on any other of the gripping assemblies 20 in FIGURE 3, 21 in FIGURE 5, 24 in FIGURE 11, and 28 in FIGURE 15, as illustrated herein.

FIGURE 14A is a cross-sectional view of the gripping assembly 26 shown in FIGURE 13, embodying an alternate design for pivotally supporting a gripping jaw 265A. Jaw 265A is pivotally supported by a jaw link 266A. Jaw link 266A has a convex end 269A which is received by and bears against a matching concave surface 267A formed in the jaw 265A. Jaw 265A is loosely secured to jaw link 266A by a pin 270A, through a loose fitting hole 271A, and is secured by snap rings 272A and 273A. The loosely fitted pin 270A and opening



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271A allow the force supplied to the jaw 265A by the jaw link 266A to be borne substantially entirely by the concave surface 267A, thereby avoiding or minimizing shear stress that would otherwise be imposed on the pin 270A. The jaw pivot design of gripping assembly 26 shown in FIGURE 14A may be used on any of the other gripping assemblies 20 in FIGURE 3; 21 in FIGURE 5; 24 in FIGURE 11; and 28 in FIGURE 15, as illustrated herein.

FIGURES 15 and 16 disclose a preferred embodiment of a jaw 300 having a jaw insert 301. The insert 301 is held within a groove 305 in jaw 300 having dovetail sidewalls 302 and 303. Other suitable groove designs (not shown) may also be used as fastening means to secure the insert 301. The outside diameter 304 of insert 301 matches groove 305 and has a curved, friction surface 309 concentric with pipe 120.

Insert 301 slides within dovetail groove 305 and sidewalls 302 and 303 with enough clearance to allow easy removal. When insert 301 is in place, cap screw 306 screws into jaw 300. A counterface 307 closely fits the head of cap screw 306 so shear loads, created as insert 301 is forced against cap screw 306 by torque applied to pipe 120, will be absorbed by the head of cap screw 306 instead of its threaded portion. An opening 308 in insert 301 allows a close fit to the head of cap screw 306.

FIGURE 17 illustrates the jaw 300 utilizing an alternate gripping segment comprising an arcuate backing segment 301A to which is secured a number of gripping pads 301B. The segment 301A is preferably secured to the jaw 300 in the same manner as is insert 301 (FIGURES 15 and 16). The gripping pads 301B are arranged to fit substantially flush with the exterior surface of the pipe 120. The gripping pads 301B are preferably made of a semi-resilient, high-friction material, such as automobile brake shoe material. Extending from the backing segment 301A between the gripping pads 301B are a number of lugs 301C. The lugs 301C assist in holding

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the gripping pads 301B against transverse movement that might otherwise result from shear forces imparted to the gripping pads 301B when torque is applied to the pipe 120 by the jaw 300.

Thus, there has been disclosed a novel power tong with improved gripping means and fluid drag assemblies that provide controlled drag on the drag rings thereby allowing the use of larger force angles, reduced radial loads on the gripping assemblies and reduced jaw loads on the pipe. This is accomplished primarily by a resultant greater initial preload of the jaw on the pipe before the pipe is torqued. This reduces teeth skidding marks on the pipe. The drag is adjustable to any predetermined amount.

Further, projection lugs and/or springs on the jaws are used to center the jaws as they retract, thus keeping the jaws out of the way of the pipes inserted either radially or axially into the gripping apparatus.

Novel positioning means, comprising friction means and/or springs, have been disclosed to control the jaws' position during extension to and retraction from the pipe.

Further, the gripping assemblies disclosed herein can be inserted into existing power tongs without modification. The prior art tongs use a five pin drag ring; however, the gripping assemblies 20, 21, 26 and 28 disclosed herein can be pivotally attached to three of the five existing pins. The assemblies leave no significant marks on the cylindrical pipe that is gripped and do not deform the gripped pipe appreciably.

Use of the present gripping assemblies allows substantially the entire pipe circumference to be encircled with the jaws. Moreover, by using three gripping assemblies in open throat tongs operating directly off the drive gear, the radial load is divided into three parts whereas in the prior art, the open throat tongs must divide the radial load into only two parts.

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With the use of the novel jaw assemblies and drag assemblies disclosed herein, the initial gripping force on the pipe is predetermined and the gripping force during operation is proportional to the applied torque. The gripping teeth or surfaces have a predetermined area, calculated from the expected maximum gripping force, that is sufficient to both prevent the pipe from being overstressed by the predetermined radial force and to prevent the yield strength of the pipe from being exceeded.

Also, the invention allows the use of removable jaw link adapters and replaceable jaw teeth so that various pipe sizes can be accommodated without replacing an entire gripping assembly for each pipe size.

Further, with the use of replaceable jaw segments as disclosed in the present invention, a much better fit of the jaw to the pipe can be obtained and the jaws may be used with many existing tongs.

The jaws disclosed herein can torque the pipe in both directions without removal from the power tongs or back-up.

The jaws disclosed herein may use teeth or other friction surfaces, or may be smooth. Further, one jaw may have teeth and the other two may be smooth, or any combination thereof may be used.

Finally, by using the gripping assembly with a spherical jaw pivot, the pipe can be gripped evenly even when it is axially misaligned with the final drive gear and drag ring. The spherical jaw pivot may be used with any of the gripping assemblies disclosed herein, on both power tongs and back-ups.

Only the preferred embodiments of the invention have been described. It should be understood that the invention is not limited to the embodiments disclosed, but is intended to embrace any alternatives, modifications, rearrangements, or substitutions of parts or elements as fall within the spirit and scope of the invention.

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## CLAIMS

1. An apparatus for gripping the surface and applying torque about the longitudinal axis of a tubular element, comprising:

a plurality of gripping assemblies for selectively gripping and applying torque about the longitudinal axis of the tubular element;

the gripping assemblies each including a jaw mounted on one end for engaging, gripping and applying torque to the surface of the tubular element;

each jaw being pivotally mounted to a gripping assembly for movement between a retracted position, for insertion and removal of the tubular element into and from the apparatus, and an extended position, for engagement with the tubular element within the apparatus;

each jaw having a generally concave gripping surface for engaging and applying torque to the tubular element, wherein the gripping surface of each jaw has a surface area for contacting the tubular element sufficiently great to grip the tubular element without exceeding the yield strength of the surface of the tubular element as the maximum gripping force is applied to the tubular member, thereby minimizing or avoiding damage to the surface of the tubular member; and

actuating means for selectively activating the gripping assemblies to extend and retract the jaws into and out of contact with the tubular member, to apply torque through the jaws about the longitudinal axis of the tubular member when the jaws contact the tubular member, to apply a gripping force to the tubular member through the jaws, wherein the gripping force varies substantially proportionately to the torque applied to the tubular member, thereby minimizing or avoiding slippage of the jaws against the tubular element.

2. The gripping apparatus of Claim 1, further comprising a jaw engagement control means responsive to initial

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activation of the gripping assemblies by the actuating means, for applying a predetermined gripping force to the tubular element through the jaws prior to application of torque to the tubular member, thereby minimizing or avoiding slippage of the jaws over the surface of the tubular member as the torque applied to the tubular member initially increases.

3. The apparatus of Claim 1 wherein each gripping assembly includes a jaw link which pivotally supports each jaw member, and further comprising positioning means interposed between each pivotal jaw member and said jaw link to control free pivotal movement of said jaw member with respect to said jaw link.

4. The apparatus of Claim 3 wherein said positioning means includes at least one spring assembly coupling said jaw member to said jaw link to control free pivotal movement of said jaw member with respect to said jaw link.

5. The apparatus of Claim 1 wherein each of said gripping assemblies further comprise:

a jaw link pivotally supported by the apparatus for movement of each jaw member between the extended and retracted positions; and

a projection extending from each end of said jaw members for engagement with the apparatus when the jaw members are retracted, to pivot the jaw members away from the tubular member.

6. The apparatus of Claim 5 wherein at least one jaw member further includes a replaceable arcuate gripping segment for gripping the tubular member, having a radius of curvature along its contacting surface substantially equivalent to the outer diameter of the tubular member, the gripping segment

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having rounded edges on the lateral ends and sides to reduce contact marks on the surface of the tubular element.

7. The apparatus of Claim 6 wherein said gripping segment includes one or more gripping pads, comprising a semi-resilient, high-friction material, for engaging and gripping said tubular element.

8. The apparatus of Claim 1 wherein at least one of said gripping assemblies further comprises:

- a jaw link member pivotally connected at one end to said actuating means;

- a roller rotatably attached to the other end of said jaw link member for contact with said actuating means;

- said actuating means displacing said roller to move the jaw link into the extended position;

- a retaining means mounted to the jaw link for securing a first and a second gripping device for engagement with the tubular member;

- a first gripping device pivotally secured to one end of the retaining means, the first gripping device including at least one of the jaws; and

- a second gripping device secured to the other end of the retaining means.

9. The apparatus of Claim 8 wherein said actuating means comprises a cam surface for moving said gripping assemblies into and out of contact with the tubular element, for applying gripping force to the assemblies and for applying rotational force to the assemblies.

10. The apparatus of Claim 9 further comprising:

- a slot having a flat support surface formed in the retaining means;

- a curved upper surface on said second gripping device; and

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means for loosely and removably attaching said second gripping device in said slot for limited movement on said curved upper surface so as to self-adjust and provide an accurate fit with said tubular element to be gripped.

11. The apparatus of Claim 1 wherein at least one of said gripping assemblies further comprises:

- a jaw link pivotally attached to said actuating means;
- pivoting means on one end of said jaw for engaging said actuating means and causing said jaw link to pivot;

- a ball joint on the other end of said jaw link;

- the jaw member having a spherical socket on one side thereof for receiving said jaw link ball joint and a contact surface on the other side for gripping the tubular element;
- and

means for loosely attaching said spherical socket of said jaw to the jaw link ball joint to enable said jaw to have limited movement about said ball joint to self-adjust and provide an accurate fit with said tubular element to be gripped.

12. The apparatus of Claim 1 wherein each of said gripping assemblies comprises:

- a jaw link pivotally attached to said actuating means;

- pivoting means on one end of said jaw link for engaging said actuating means and causing said jaw link to pivot; and

- said jaw link including a removable adapter segment pivotally supporting one of said jaw members, said adapter being variable in size to allow said gripping assembly to grip different sized tubular elements.

13. The apparatus of Claim 1 wherein at least one of the jaws further comprises:

- a slot having a flat supporting surface, formed on the face of the jaws;

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a gripping segment having a curved upper surface;

means for loosely and removably attaching the arcuate gripping segment in the slot for limited movement on said curved upper surface to self-adjust and provide an accurate fit with said tubular element surface.

14. An open throat apparatus for receiving a cylindrical object with a tubular surface through said open throat and gripping said cylindrical object for rotation, said apparatus comprising:

a body member having a gate for radial insertion of said cylindrical object;

a drive ring rotatably mounted within the body member and having an opening for radial insertion of said cylindrical object;

a drag ring rotatably mounted within the body member and having an opening for radial insertion of said cylindrical object;

a plurality of spaced gripping assemblies slidably mounted in said drag ring for radial movement toward and away from said cylindrical object inserted in said drag ring opening, the rotation of said drive ring with respect to said drag ring providing said radial movement of said gripping assemblies; and

a plurality of jaws pivotally mounted on said assemblies and having arcuate gripping surface of sufficient length to substantially encircle the tubular surface of said cylindrical object, for gripping and rotating said cylindrical object, said jaws each having a gripping surface with a surface area sufficiently great that the yield strength of the surface of the cylindrical object is not exceeded as the maximum gripping force is applied to the cylindrical object.

15. The apparatus of Claim 14 wherein the arcuate gripping surfaces of the jaws are formed by a removable gripping



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segment mounted on each jaw, including one or more gripping pads, comprising a semi-resilient, high-friction material, for engaging and gripping said cylindrical object.

16. The apparatus of Claim 14 wherein three gripping assemblies are substantially equally spaced about the drag ring, thereby distributing the radial load on the assemblies and drive ring substantially equally.

17. The apparatus of Claim 14 further including control means coupled to said drag ring for applying an adjustable drag thereto so as to prevent said drag ring from turning until said gripping assemblies are urged against said tubular surface with a predetermined radial gripping force prior to the rotation of said cylindrical object by said drive ring to prevent skidding of said arcuate gripping surface on said tubular surface.

18. The apparatus of Claim 14 wherein said jaws each further comprise:

at least one arcuate gripping segment having a radius matching the tubular surface to be gripped; and

means for removably attaching at least one of said arcuate gripping segments to said jaw to enable said gripping segment to be replaced as necessary.

19. The apparatus of Claim 18 further including:

a flat surface on the bottom of said slot;

a curved upper surface on each of said arcuate gripping segment; and

means for loosely and removably attaching said arcuate gripping segment in said slot such that such arcuate gripping segment has sufficient limited movement on said curved upper surface to self-adjust and provide an accurate fit with said tubular surface.

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20. The apparatus of Claim 14, wherein at least one of the gripping assemblies further comprises:

a crosshead for radial movement within the drag ring;

a jaw adapter having a ball joint on one end and a male connector at the other;

an opening in said crosshead for removably receiving said male connector;

a jaw having a gripping surface and a spherical socket for receiving said ball joint; and

means for loosely attaching said jaw adapter ball joint to said jaw spherical socket to enable said jaw to have limited movement about said ball joint to self-adjust and provide an accurate fit with said tubular surface to be gripped.

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21. A jaw apparatus for use in a machine to apply or resist torque applied to a pipe to thread or unthread one segment of pipe relative to an adjacent segment, the improvement comprising:

a plurality of jaws;

pivot means mounting each of said jaws for pivotal movement relative to the pipe to be gripped;

each said jaw including gripping means having at least one outer gripping face formed to substantially conform with and adapted to engage the outside diameter of the pipe to be torqued;

whereupon the pressure applied by each of said gripping means is resultantly substantially uniform over said outer gripping face of each of said gripping means.

22. The jaw apparatus of claim 21 wherein each said gripping means comprises a pair of gripping pads mounted to each of said jaws.

23. The jaw apparatus of claim 22 wherein each of said gripping pads also has an inner surface.

24. The jaw apparatus of claim 23 wherein each of said jaws has a pair of recesses for receiving said pair of gripping pads, each of said recesses having a recess wall and adapted to receive one of said gripping pads with its said inner surface disposed therein.

25. The jaw apparatus of claim 24 further comprising alignment means for allowing alignment of each said pad into substantially flush engagement with the pipe.

26. The jaw apparatus of claim 25 whereupon the pressure applied by each of said gripping pads is substantially uniform over said outer gripping face of each of said gripping pads.

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27. The jaw apparatus of claim 21 further comprising alignment means received by each of said jaws for compensating for axial misalignment of said outer gripping face of each said gripping means with the pipe.

28. The jaw apparatus of claim 21 wherein each said gripping means comprises at least one gripping pad mounted to each of said jaws.

29. The jaw apparatus of claim 28 wherein each said gripping pad has an inner surface.

30. The jaw apparatus of claim 29 wherein each of said jaws has a recess for receiving each of said gripping pads, each of said recesses having a recess wall and adapted to receive one of said gripping pads with its said inner surface disposed therein.

31. The jaw apparatus claim 27 whereupon the pressure applied by each of said gripping means is resultantly substantially uniform over said outer gripping face of each said gripping pad.

32. The jaw apparatus of claim 30 further comprising alignment means received by each of said jaws for providing a substantially even distribution of force along the entire length of each of said gripping pads upon an uneven force being applied on each of said gripping pads when there is contact between each of said gripping pads and the pipe.

33. The jaw assembly of claim 32 whereupon the pressure applied by each of said gripping pads is resultantly substantially uniform over said outer gripping face of each of said gripping pads.

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34. A machine for applying or resisting a turning force to a pipe comprising:

a frame;

an actuating member mounted to said frame;

drive means connected to said frame for selective movement of said actuating member;

a drag ring supported by said frame;

a plurality of jaws pivotally mounted to said drag ring and operably connected to said actuating member;

means mounting said actuating member for permitting relative movement of said actuating member with respect to said drag ring to cause said jaws to pivot and move toward and into contact with the pipe;

each jaw further comprising:

each said jaw including gripping means having at least one gripping face formed to substantially conform with and adapted to the outside diameter of the pipe to be torqued;

whereupon the pressure applied by each of said gripping means is resultantly substantially uniform over said outer gripping face of each of said gripping means.

35. The jaw apparatus of claim 34 wherein each said gripping means comprises a pair of gripping pads mounted to each of said jaws.

36. The jaw apparatus of claim 35 wherein each of said gripping pads also has an inner surface.

37. The jaw apparatus of claim 36 wherein each of said jaws has a pair of recesses for receiving said pair of gripping pads, each of said recesses having a recess wall and adapted to receive one of said gripping pads with its said inner surface disposed therein.

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38. The jaw apparatus of claim 37 further comprising alignment means for allowing alignment of each said pad into substantially flush engagement with the pipe.

39. The jaw apparatus of claim 38 whereupon the pressure applied by each of said gripping pads is substantially uniform over said outer gripping face of each of said gripping pads.

40. The jaw apparatus of claim 34 further comprising alignment means received by each of said jaws for compensating for axial misalignment of said outer gripping face of each said gripping means with the pipe.

41. The jaw apparatus of claim 34 wherein each said gripping means comprises at least one gripping pad mounted to each of said jaws.

42. The jaw apparatus of claim 41 wherein each said gripping pad has an inner surface.

43. The jaw apparatus of claim 42 wherein each of said jaws has a recess for receiving each of said gripping pads, each of said recesses having a recess wall and adapted to receive one of said gripping pads with its said inner surface disposed therein.

44. The jaw apparatus claim 37 whereupon the pressure applied by each of said gripping means is resultantly substantially uniform over said outer gripping face of each said gripping pad.

45. The jaw apparatus of claim 44 further comprising alignment means received by each of said jaws for providing a substantially even distribution of force along the entire length of each of said gripping pads upon an uneven force

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being applied on each of said gripping pads when there is contact between each of said gripping pads and the pipe.

46. The jaw assembly of claim 45 whereupon the pressure applied by each of said gripping pads is resultantly substantially uniform over said outer gripping face of each of said gripping pads.

47. The machine of claims 34 or 40 wherein:

said actuating member is formed having a plurality of rounded depressions and camming surfaces;

each of said jaws has a roller mounted therewith;

whereupon each of said jaws is retracted when each roller is disposed in one of said rounded depressions and each of said jaws is actuated to move toward the pipe when relative rotation between said actuating member and said drag ring results in radial displacement of each of said jaws as each of said rollers is displaced out of one of said rounded depressions and moves along one of said camming surfaces.

48. The machine of claim 34 or 40, wherein:

each of said jaws is connected to said drag ring by a pivot pin mounted therewith;

a plurality of links, one of which is pivotally mounted to each of said jaws to said drag ring;

said actuator member having a plurality of gear teeth;

each of said links having a plurality of gear teeth meshing with said gear teeth on said actuating member;

whereby, upon relative rotation between said actuating member and said drag ring, each of said links pivots about its pivot pin so that each of said jaws is moved toward or away from the pipe.

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49. A machine for applying or resisting a turning force to a pipe comprising:

a frame;

an actuating member mounted to said frame;

drive means mounted to said frame for selective movement of said actuating member;

a drag ring supported by said frame;

a plurality of jaws movably mounted to said drag ring and operably connected to said actuating member;

means mounting said actuating member for permitting relative movement of said actuating member with respect to said drag ring to cause said jaws to move toward the pipe;

each jaw further comprising:

each of said jaws including a gripping means having at least one gripping face formed to substantially conform to the outside diameter of the pipe to be torqued;

whereupon the pressure applied by each of said gripping means is resultantly substantially uniform over said outer gripping face of each of said gripping means;

each of said jaws connected by a pivot pin mounted therewith;

a plurality of links, one of which is pivotally mounted to each of said jaws and to said drag ring;

said actuator member having a plurality of gear teeth;

each of said links having a plurality of gear teeth meshing with said gear teeth on said actuating member; and

whereby, upon resistive rotation between said actuating member and said drag ring, each of said links pivots about its pivot pin so that each of said jaws is moved toward or away from the pipe.

50. The jaw apparatus of claim 49 wherein each said gripping means comprises a pair of gripping pads mounted to each of said jaws.



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51. The jaw apparatus of claim 50 wherein each of said gripping pads also has an inner surface.

52. The jaw apparatus of claim 51 wherein each of said jaws has a pair of recesses for receiving said pair of gripping pads, each of said recesses having a recess wall and adapted to receive one of said gripping pads with its said inner surface disposed therein.

53. The jaw apparatus of claim 52 further comprising alignment means for allowing alignment of each said pad into substantially flush engagement with the pipe.

54. The jaw apparatus of claim 53 whereupon the pressure applied by each of said gripping pads is substantially uniform over said outer gripping face of each of said gripping pads.

55. The jaw apparatus of claim 54 further comprising alignment means received by each of said jaws for compensating for axial misalignment of said outer gripping face of each of said gripping means with the pipe.

57. The jaw apparatus of claim 49 wherein each said gripping means comprises at least one gripping pad mounted to each of said jaws.

58. The jaw apparatus of claim 57 wherein each said gripping pad has an inner surface.

59. The jaw apparatus of claim 58 wherein each of said jaws has a recess for receiving each of said gripping pads, each of said recesses having a recess wall and adapted to receive one of said gripping pads with its said inner surface disposed therein.

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60. The jaw apparatus claim 56 whereupon the pressure applied by each of said gripping means is resultantly substantially uniform over said outer gripping face of each said gripping pad.

61. The jaw apparatus of claim 59 further comprising alignment means received by each of said jaws for providing a substantially even distribution of force along the entire length of each of said gripping pads upon an uneven force being applied on each of said gripping pads when there is contact between each of said gripping pads and the pipe.

62. The jaw assembly of claim 61 whereupon the pressure applied by each of said gripping pads is resultantly substantially uniform over said outer gripping face of each of said gripping pads.

63. The jaw assembly of claims 49 or 55 further comprising means to retard the pivotal movement of each of said jaws relative to the corresponding one of said links to which it is pivotally mounted.

64. The jaw assembly of claim 63 wherein each said jaw further comprises positioning means for pivotally reorienting said jaw upon actuation of said actuating member in the absence of the pipe, to selectively position said jaws to allow the machine to apply or resist turning forces in either a clockwise or counterclockwise direction.

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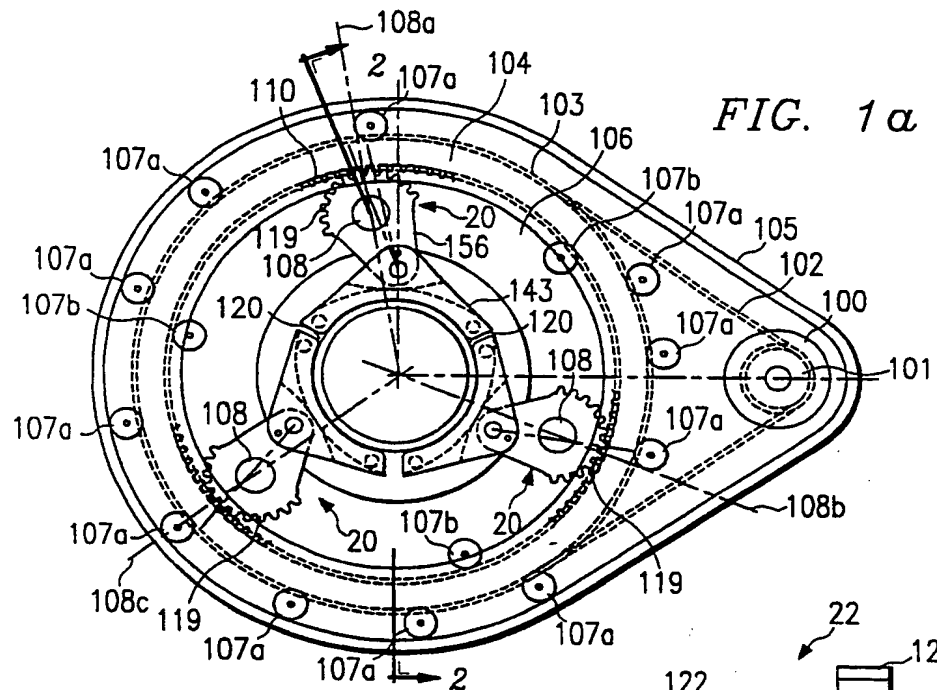


FIG. 1a

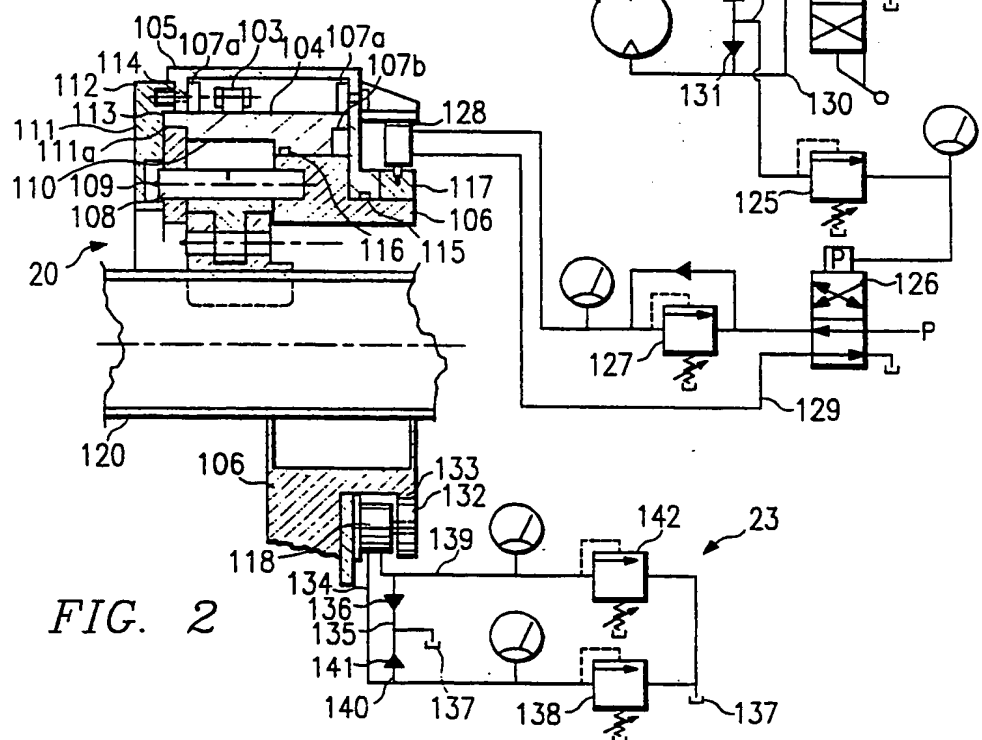
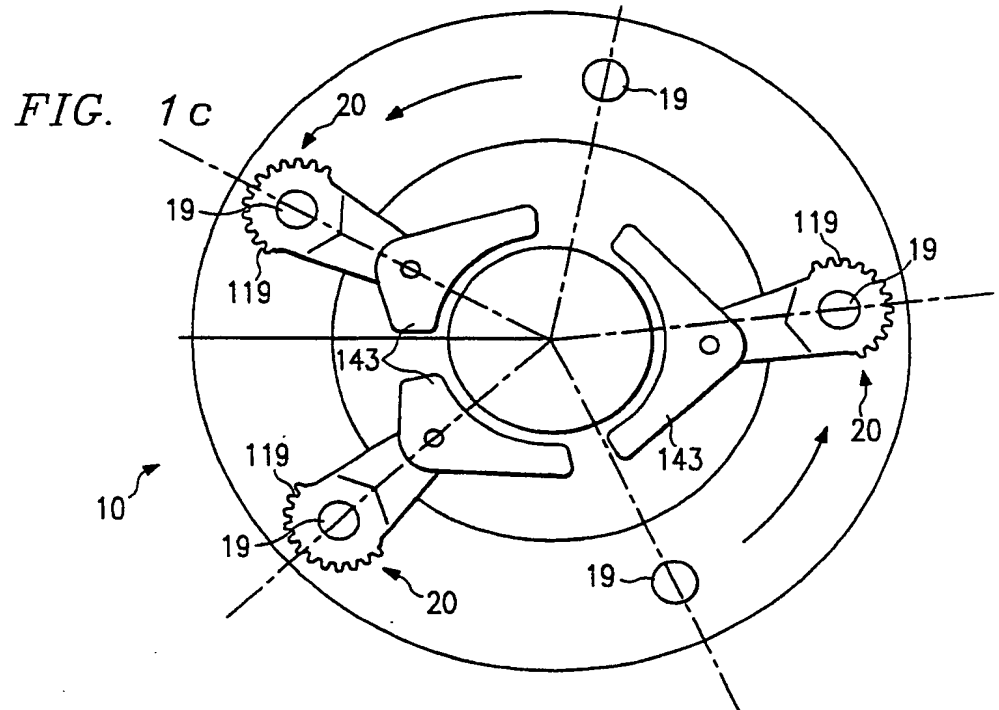
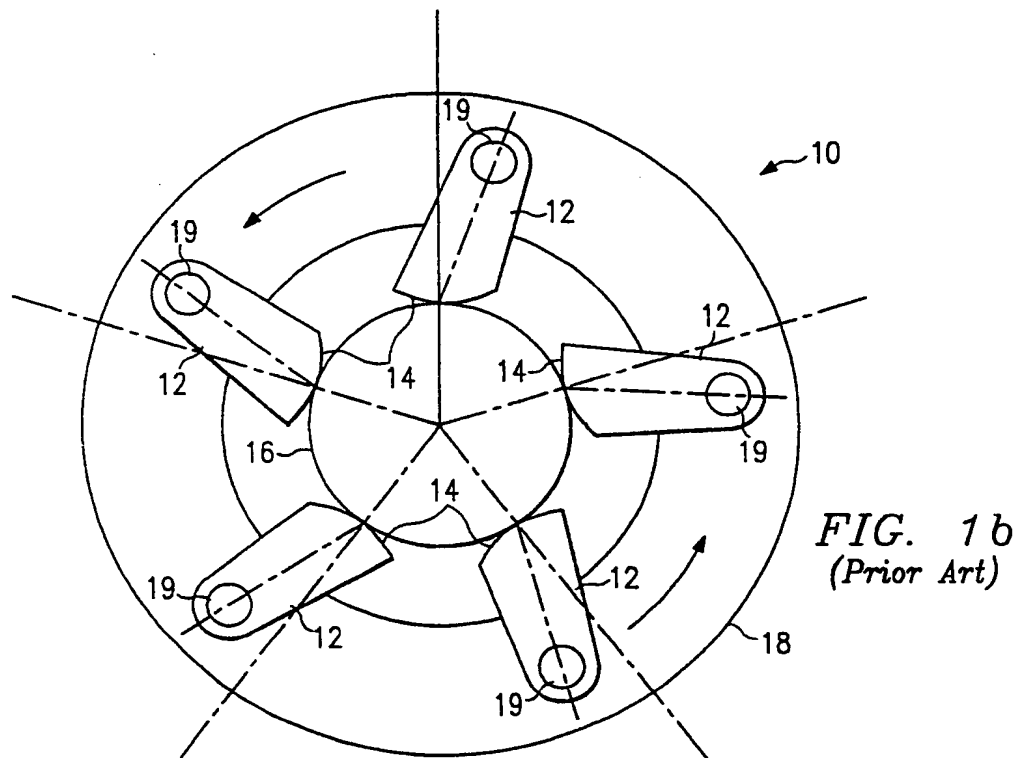
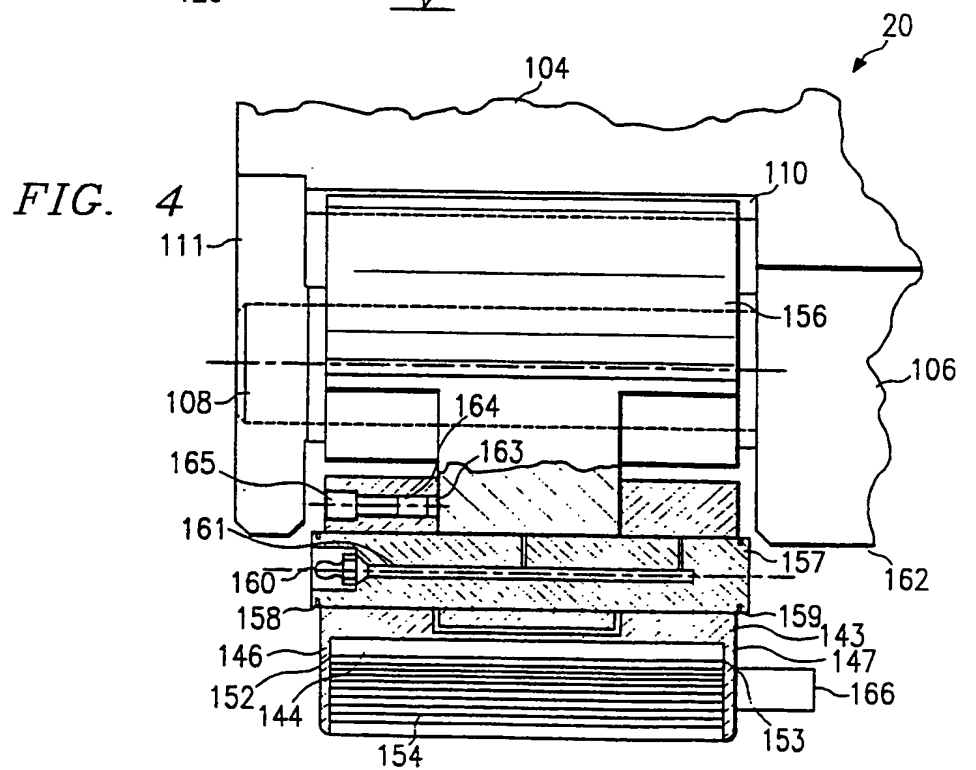
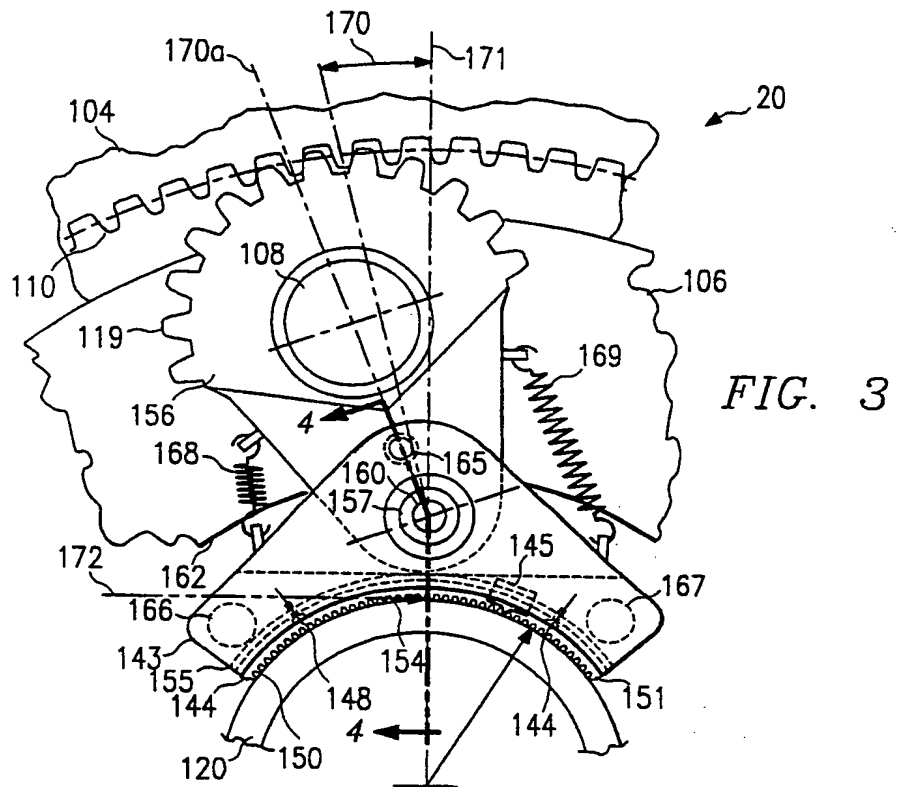


FIG. 2

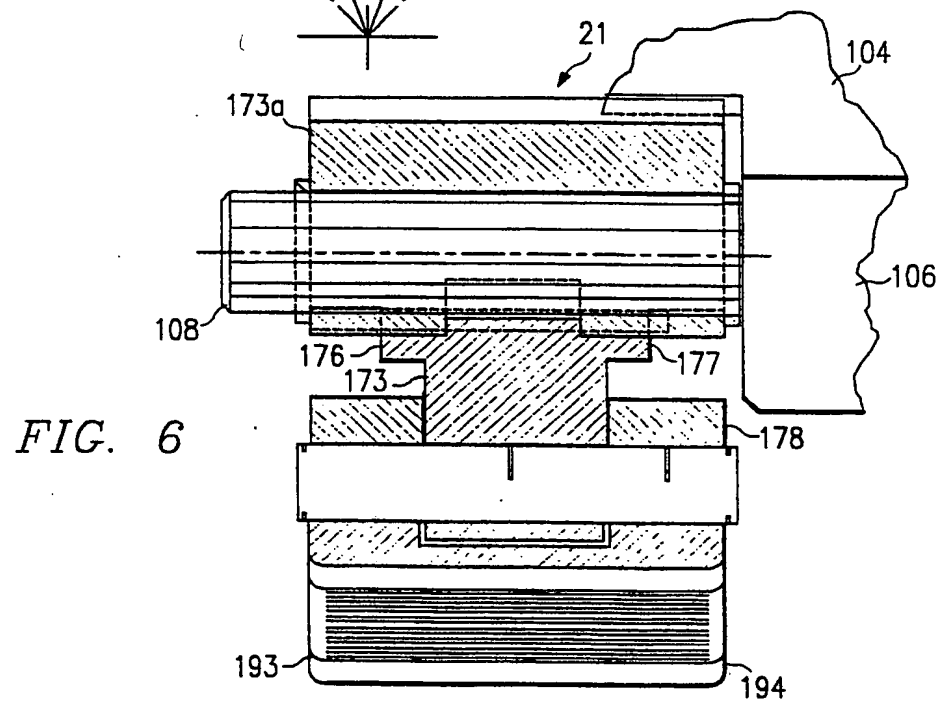
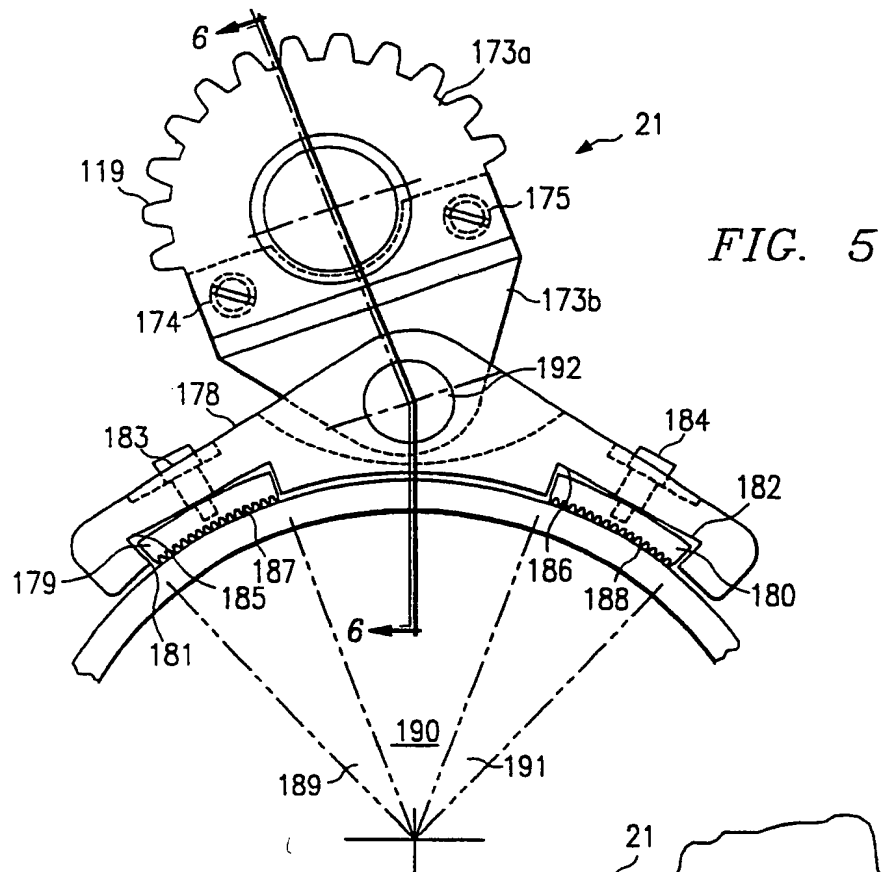
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FIG. 7

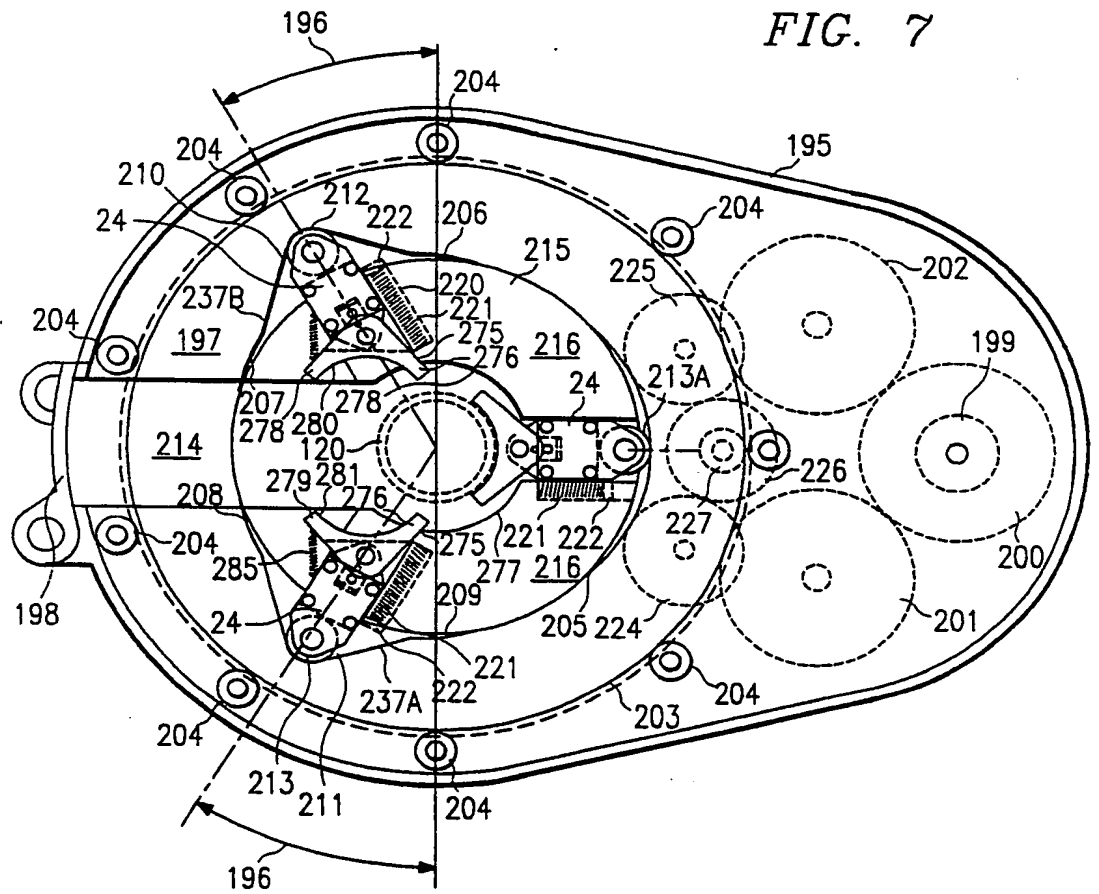
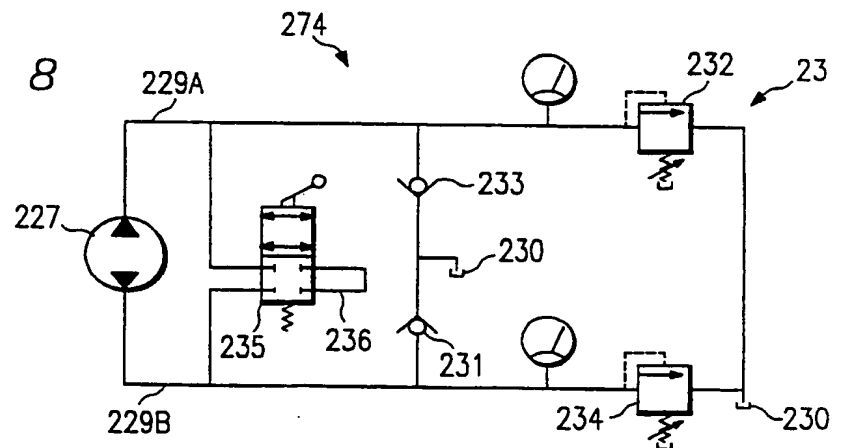


FIG. 8



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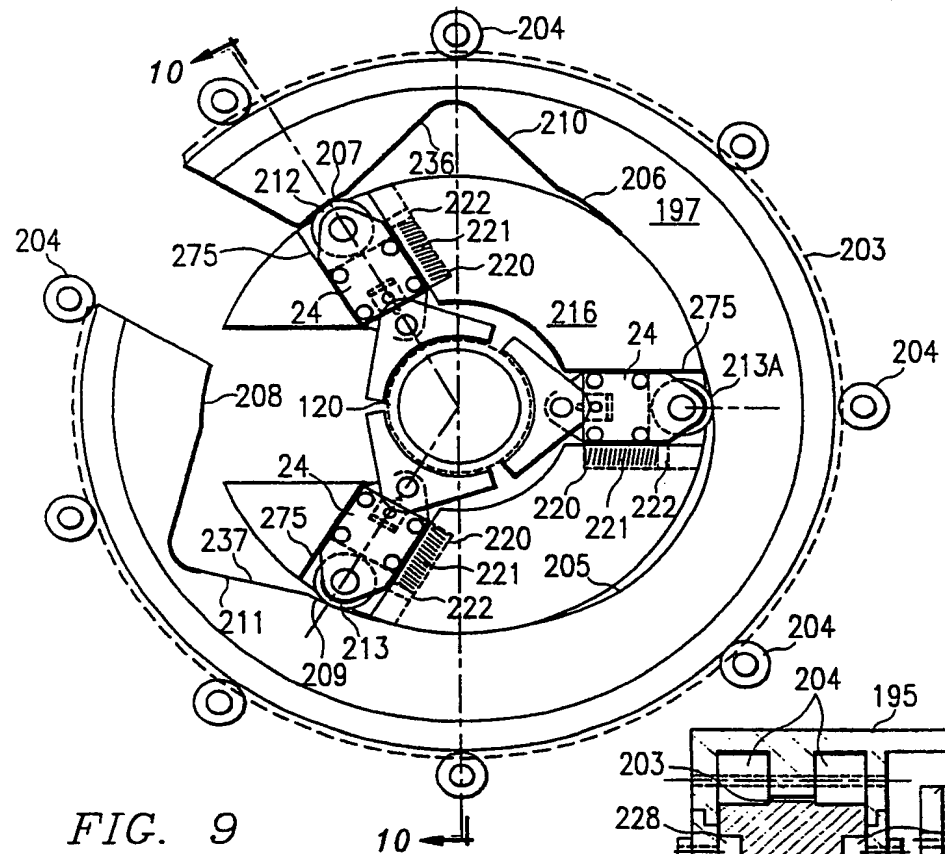
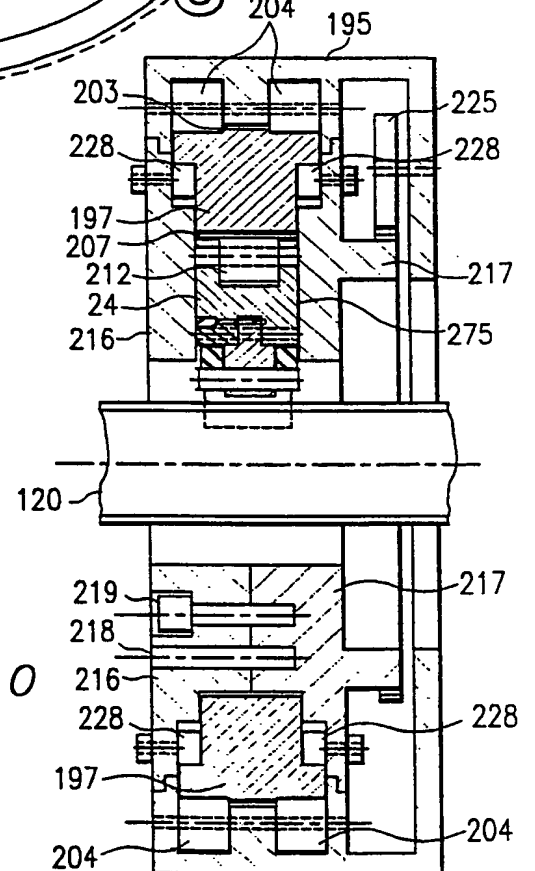


FIG. 10





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FIG. 11

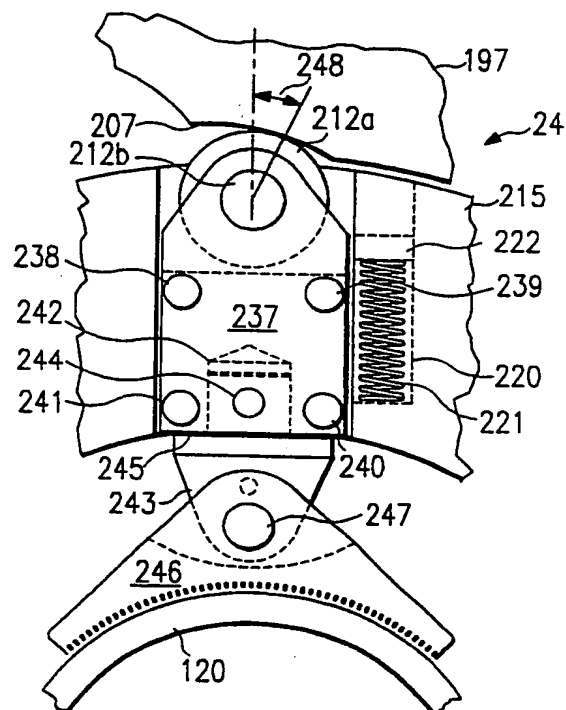
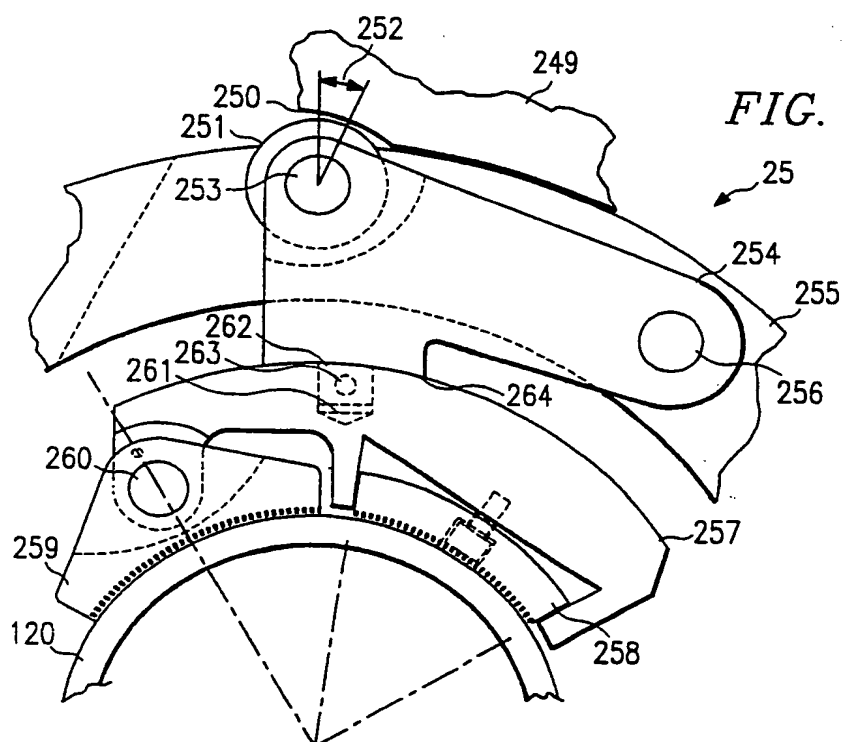


FIG. 12



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FIG. 13

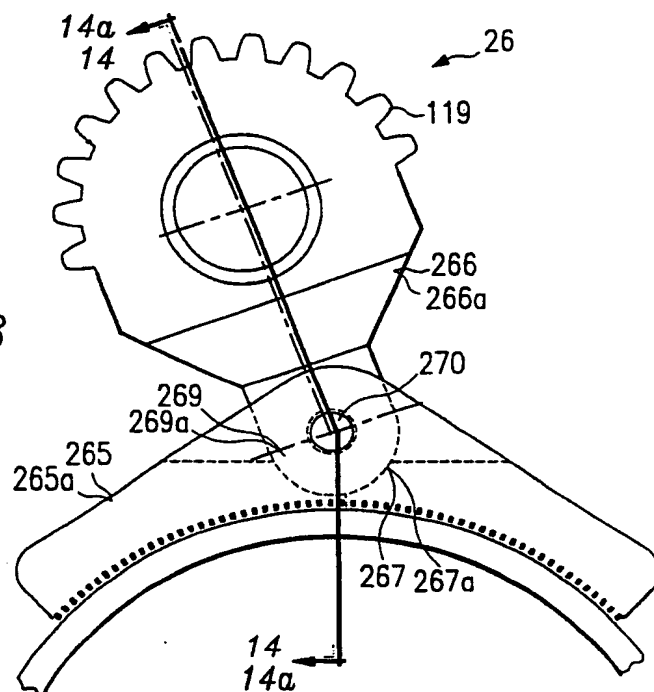


FIG. 14

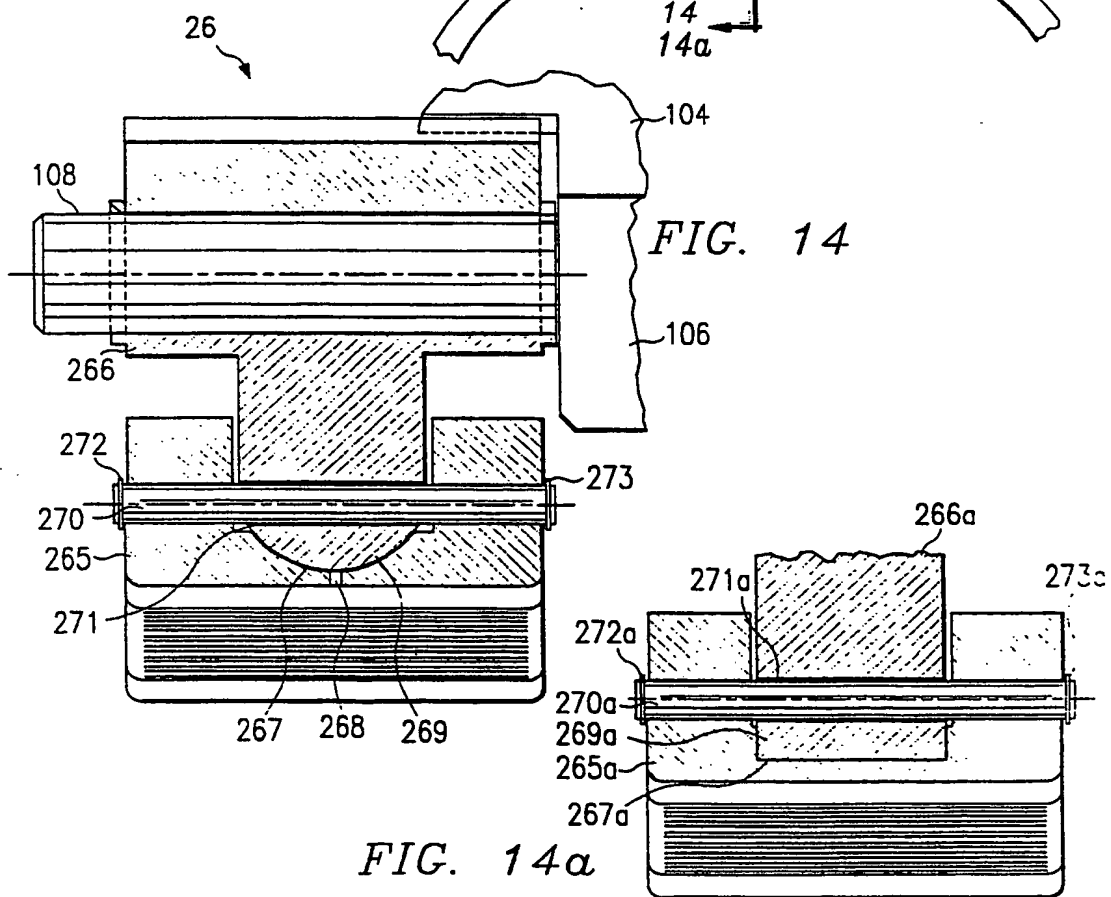
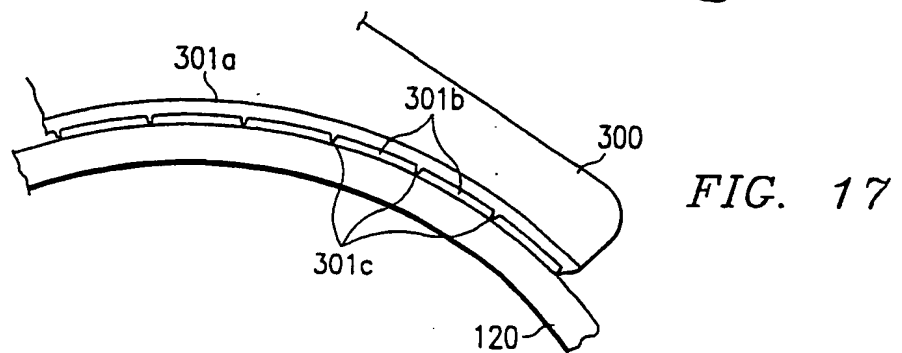
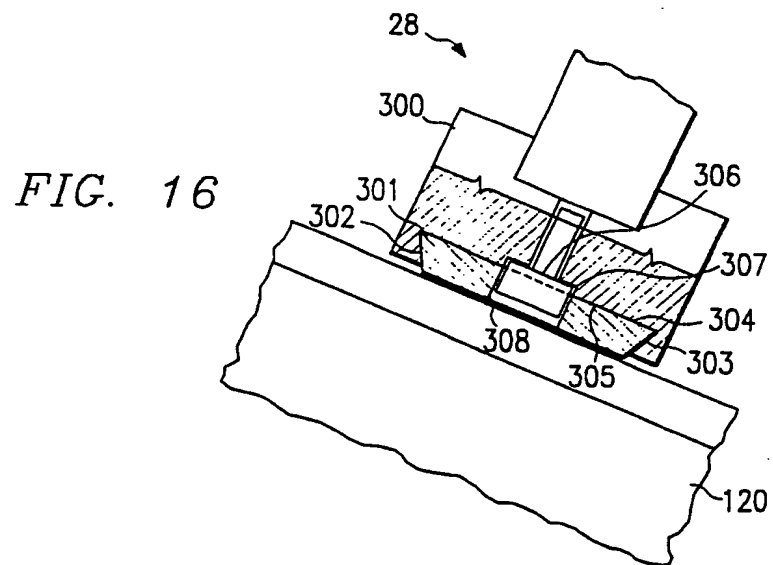
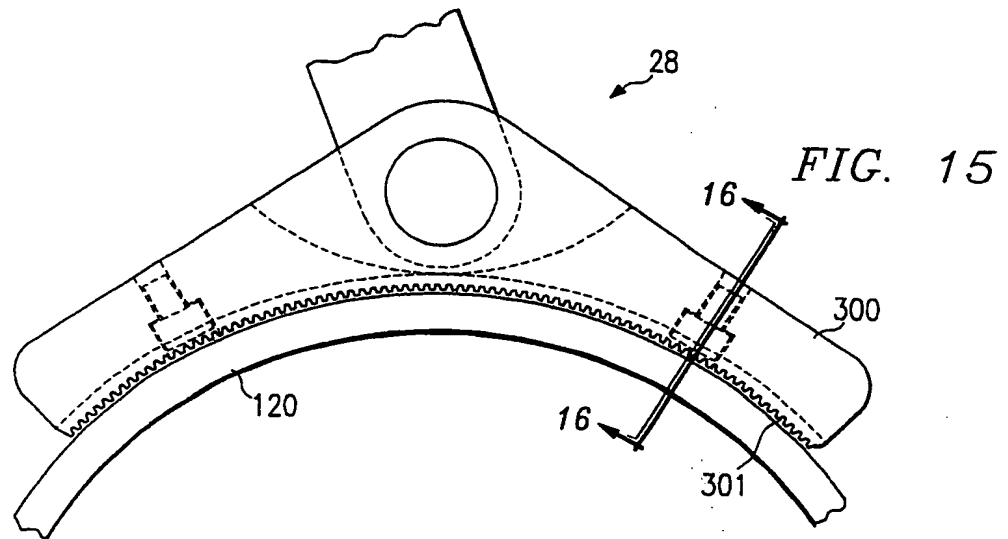


FIG. 14a

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# INTERNATIONAL SEARCH REPORT

International Application No PCT/US90/07066

<b>I. CLASSIFICATION OF SUBJECT MATTER</b> (If several classification symbols apply, indicate all) <sup>3</sup>		
According to International Patent Classification (IPC) or to both National Classification and IPC		
IPC(5): B25B 13/50		
US CL.: 81/57.33		
<b>II. FIELDS SEARCHED</b>		
Minimum Documentation Searched <sup>4</sup>		
Classification System	Classification Symbols	
US	81/57.33, 57.11, 57.14, 57.2, 57.3, 57.34, 57.35, 421, 422 423, 424, 424.5, 186 279/106, 20	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched <sup>5</sup>		
<b>III. DOCUMENTS CONSIDERED TO BE RELEVANT</b> <sup>14</sup>		
Category <sup>6</sup>	Citation of Document, <sup>10</sup> with indication, where appropriate, of the relevant passages <sup>17</sup>	Relevant to Claim No. <sup>18</sup>
<u>X</u> <u>Y</u>	US, A, 4,869,137 (SLATOR) 26 September 1989	1-3,5-8,21-46, 48-64 4,11-13,20
Y	US, A, 3,196,717 (SHEPPARD) 27 July 1965	4
X	US, A, 4,401,000 (KINZBACH) 30 August 1983	9,10,14-19,47
<p><sup>15</sup> Special categories of cited documents:</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"&amp;" document member of the same patent family</p>		
<b>IV. CERTIFICATION</b>		
Date of the Actual Completion of the International Search <sup>1</sup>	Date of Mailing of this International Search Report <sup>2</sup>	
15 JANUARY 1991	<b>26 FEB 1991</b>	
International Searching Authority <sup>1</sup>	Signature of Authorized Officer <sup>10</sup> <i>Nguyen Ngoc-Ho</i>	
ISA/US	For LAWRENCE CRUZ <b>NGUYEN NGOC-HO</b> INTERNATIONAL DIVISION	